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A TYPICAL PALESTINE SHEPHERD WITH SHEEP.—[SEE PAGE 297.]

TELEGRAPHY AND TELEPHONY.—II.*

RECENT DEVELOPMENTS.

BY SIR JOHN GAVEY, C.B., M.INST.C.E.†

Concluded from Supplement No. 1817, Page 279.

So FAR, we have only considered the apparatus for the transmission and receipt of telegrams on land lines; but before we proceed with our subject it is necessary to deal with the behavior of the conductors by means of which electrical energy is transmitted from one station to another. In considering this branch of our subject, there are several factors to take into account, each of which may profoundly modify the results according to the circumstances under which the transmission takes place. These factors are conductor-resistance, electrostatic capacity, self-induction, and insulator-resistance, or its reciprocal leakance.

Resistance wastes the effective electrical energy by degrading it into heat, and its sole effect is to reduce the amount of current available at the distant end. Electrostatic capacity converts a portion of the kinetic energy into potential energy, which is restored to the circuit on the cessation of the current, and it has the effect of retarding the receipt of the first portion of each signal, and extending its duration when the line is disconnected from the source of energy. To illustrate, assume the case of a conductor with high capacity—say a length of submarine cable. If the far end is disconnected, then, on making contact with one pole of a battery, the other pole of which is to earth, there is a rush of current into the cable, which continues until the latter is charged to the potential of the battery. When the battery is disconnected from the line, and replaced by the earth, the charge leaks out in the form of a reverse current. If, when the battery contact is made, the far end of the line is to earth, the initial portion of the current is taken up in establishing the cable charge, while only a fraction of its ultimate value trickles out at the distant end a short interval after the battery contact is made. The duration of this interval depends on the capacity and resistance of the line. When the full charge has accumulated along the circuit, the full current dependent on the potential and the resistance flows along the conductor. On replacing the battery by earth the charge flows out at both extremities.

Self-induction may be taken as the analogue of mechanical inertia. The first effect when a source of electrical energy is connected to a conductor is to establish a magnetic field in planes at right angles to the conductor, and this retards the period when the full strength of the current is established. Conversely, on the cessation of the primary current, the magnetic field closes in on the conductor, and generates a transient current in a direction which tends to prolong the original current.

Leakance causes a loss of current that should otherwise be utilized in actuating the distant apparatus. *Per contra*, it exercises a beneficial effect in high-capacity lines in facilitating the static discharge, but so far it has not been found practicable to utilize the effect without introducing other evils. These somewhat elementary facts, which, of course, are well understood, have been referred to so as to maintain the logical sequence of our subject, for they govern the limiting distances and speeds at which electrical communication of all types can be maintained, and they account for the very different results obtained on overhead, underground, and submarine circuits, respectively.

Overhead wires, for many years almost exclusively used for telegraphy, and even now the only conductors that serve satisfactorily for really long-distance telephony, possess the advantages of low resistance, which can be diminished to any reasonable degree by the use of copper, and by increasing the size of the conductor; their electrostatic capacity is small—say from 0.013 to 0.014 microfarad per mile—and their self-induction is relatively great. Their use admits of attaining the maximum speed in telegraphy; and perhaps the most important limiting factor in this case is the self-induction of the receiving apparatus which would be a useful factor if distributed over the line, but which tends to act as a choking-coil when massed at the extremity.

This self-induction, in the case of the Wheatstone receiver, amounts to as much as one henry, and its effect in prolonging the current, combined with that due to the capacity of the line, is neutralized to some extent by inserting a shunted condenser between the instrument and the earth. As already stated, this admits of a maximum speed of 450 words per minute —a relatively low figure compared with that attained by the electro-chemical receiver.

Overhead telegraphs are subject to serious interruptions, due to the falling of trees during heavy storms, and to breakdowns arising from a combination of sleety snow and gales of wind, against which no engineering precautions are of any avail. On the other hand, until recently, underground wires, owing to their capacity, which reached 0.3 microfarad per mile when insulated with gutta percha, and the great cost of the material, were only used in special cases where strategical or other imperative reasons rendered such a course necessary. The introduction of dry paper as an insulating material profoundly modified the situation. The electrostatic capacity of suitable paper is not very much greater than that of air, and wires wrapped with paper, cabled, thoroughly dried, and inclosed in a lead sheath, are not only available for long underground telegraphs, but it is not too much to say that without them the modern development of the telephone would have been wholly impossible. The post office has, within the last few years, laid 138,000 miles of paper-insulated wire underground for telegraph purposes alone, and, to illustrate the bearing of this material on telephone progress, it may be added that, between 1900 and 1902, before a single subscriber had been served, the post office laid 240,000 miles of wire underground as the first step in the development of the London system, and from its central exchange in Carter Lane 210 ducts radiated to various portions of the center to be served from that point, and although at that period 36,000 wires only were led into the building, the spare duct capacity admitted, as the system grew, of increasing this number to 125,000 or 150,000 wires. The mileage of underground wire laid by the post office in Great Britain for telephones is now increased to 521,000 miles. By no other known means could such a service have been provided, and these facts emphasize the connection between paper insulation and telephone development.

Submarine telegraphy is not susceptible of the many developments that have been possible with land lines. The high electrostatic capacity, varying from 0.3 to 0.4 microfarad per mile, and the very long lengths that are necessary to connect the great continents of the world, render the use of any but the most delicate apparatus impossible on long cables. The receiving instruments originally invented by the late Lord Kelvin, then Sir William Thomson, are still the only apparatus available for the reception of messages on long transcontinental cables, and, so far, it has not been found possible to materially increase the speed of working except, of course, by increasing the dimensions and cost proportionately.

Attention has been devoted to eliminating disturbing elements and perfecting the signals by the use of automatic transmission and by the use of curbing devices at the receiving end. The introduction of repeaters at intermediate points where cables land at suitable localities has recently become possible, and it may be that methods of distributed induction, referred to later, may ultimately be of some value; but this subject is not ripe for consideration. Short cables present no difficulties that cannot be overcome for relatively rapid working; but their electrostatic capacity limits materially the distance over which telephone working is possible, as I will show presently.

Telephony.—In telegraphy, when transmitting through an overhead line, the frequency of the current alternations is only 180 per second for 450 words per minute, and the current has actuated the apparatus at the further end, before the battery connection has ceased. Another condition, however, is introduced when a conductor is used for telephonic speech, in which a maximum frequency of 1,800 to 2,000 vibrations per second has to be dealt with. In these cases the transmission from the telephone assumes complex wave-forms, and the effect of even a moderate capacity becomes far more marked than in the case of telegraphic transmission. If a simple wave impulse were emitted in a circuit containing neither capacity nor inductance, it would maintain its form, and it would only lose in amplitude owing to the waste of energy in heating the conductor. With much capacity in the circuit, however, the wave tends to elongate; and if the capacity be sufficiently great, and the line sufficiently long, the following wave overtakes the lagging tail of the previous one, they blend more or less together, and, having lost their distinctive character, they fail to impress on the receiving telephone the distinct character of the sound from which they emanate. Of course, if this happens with a simple sine wave, this damping action is intensified in the complicated wave-forms which speech assumes. Various vowel and consonant sounds obtained on an oscillograph show the wave as it enters and leaves a standard telephone cable may vary up to twenty miles in length. The amplitude is greatly reduced, and some of the overtones cut off, although perfectly good and articulate speech is obtainable under these conditions.

Of course, the loss of the overtones means diminution of the timbre of the voice; in other words, though speech may still be possible, the voice ultimately becomes less recognizable until, when a certain limit is passed, if the resistance of the conductor be not too great, it may degenerate into a low-toned imitation of speech, or with the smaller conductors, which are used for city work, the attenuation rapidly lowers the volume of sound until it becomes unrecognizable. A few years ago I had, in conjunction with the engineer-in-chief of the National Company, Mr. Gill, to fix certain standards of speech which had to be maintained by the two administrations working the telephone system in this country, and after a series of practical tests, which were found to accord most closely with theoretical calculations, we found results to represent the practical limits of ordinary commercial speech on various classes of conductor, both overhead and underground, when no special steps were taken by artificial means to overcome the deleterious effects of capacity. I have, however, referred to self-induction as the analogue of inertia in mechanics, and obviously, therefore, if it were possible to endow the circuit in which a wave was in movement with sufficient self-induction to prevent the tailing and consequent distortion of its form, the limit of speech would be materially increased, as the attenuation due to resistance alone would have to be provided for. Now it is possible to achieve this result to a certain extent by adding artificially to the self-induction of telephone cables, technically termed loading. The ideal method would be to increase the self-induction uniformly throughout, and attempts have been made to effect this by lapping a copper conductor with thin iron wire or tape of a high magnetic permeability. Another method consists in distributing magnetic coils at uniform distances of a mile or two apart throughout the length of the line. Under these conditions the distance over which speech is possible has been increased from two and a half to three and a half times. The British Post Office has recently laid a cable with distributed inductance between England and France which will increase the range of speech about four times as compared with a similar type of unloaded cable.

The rapid and enormous development of the telephone service that has taken place throughout the world within the last few years is a remarkable achievement of the electrical engineer. The principle of the microphone, which converts sound vibrations into the electrical vibrations, and of the telephone, which reconverts the electrical into sound vibrations, are so well known that I need not dwell further on the subject than to point out that Graham Bell's telephone, as it left his hands in 1876, is essentially the same instrument as he gave it to the world, slightly improved in mechanical construction; but all the other adjuncts of a complete telephone service have been profoundly modified; and we are not yet in sight of finality.

The problem of connecting two subscribers' lines at an exchange is a very simple one when a small number of subscribers only are concerned. An electrical indicator of the shutter type to announce a call, flexible conductors to connect any two lines by means of plugs and spring-jacks, electrical bells to call up subscribers, and the equipment is complete. The problem is a serious one, however, when, as is now the case, the number of telephone subscribers in a large city runs into five, or frequently six, figures, when the area covered, like that in London, amounts to 640 square miles, when it has to be served by 60 to 100 separate exchanges, between all of which intercommunication must be provided with the minimum amount of delay, and when an exacting public expects to get through to any subscriber on a large system immediately the call is made, or sooner. Add to this the interurban communication between all the principal cities in the country, and the fact that practically the major part of the business of the twenty-four

* English Mechanic and World of Science.

† The "James Forrest" lecture, delivered before the Institution of Civil Engineers, June 22nd, 1910.

hours is concentrated in about two and a half hours in the morning, and a similar period in the afternoon, and the difficulties to be solved become faintly apparent, even to the uninitiated.

Apart from minor improvements in the calling-indicators, and other details, each of which added its quota to the gradual perfection of the service, perhaps the most marked advance that was made, when exchanges grew in size, was the introduction of the so-called multiple-switch. Before its introduction, each operator had the care of, say, 100 subscribers, whose lines terminated in front of her. She could connect any two of these 100 directly; but as soon as a connection had to be made to another position, a subsidiary junction line had to be brought into use, and the services of another operator invoked to complete the connections; and as the number of subscribers on the exchange increases the number of junction lines interconnecting, the whole of the positions increased in a geometrical ratio. This became a very serious element in cost, and the complications, and consequent delay, in completing the connections between subscribers on various positions gradually increased in a much greater proportion than the number of subscribers. To obviate this difficulty, the so-called multiple-switch was designed, and it provided that any operator responsible for answering the calls of, say, 100 subscribers, could connect any one of these direct to any other subscriber on the same exchange, even if the number reached 10,000 or upward. To make this clear, it is advisable to repeat that a subscriber's line terminates on a small compound spring called a "jack"; and, if a flexible metallic cord terminating in two plugs is provided, on the insertion of one of the plugs into one subscriber's jack, and the other in a second jack, both of the subscribers find themselves in direct communication with one another. In the multiple-board the lines of, say, 100 subscribers are terminated, as before stated, on one operator's position; but on a large panel above these local jacks the whole of the 10,000 or more lines are connected to a series of jacks within reach of the operator, and this is repeated at every operator's position, so that a line on any position can be directly connected with any of the other lines on the exchange by the operator who answers the call. On the upper section of a multiple-board of this type are drop-indicators, the shutters of which, by falling, indicate the call of a subscriber whose line terminates on that position; the panels next below have the multiple-jacks giving access to all the subscribers, the third panel the jacks of the subscribers served by the operator, and the plugs for making the connections below. In other arrangements of the multiple-board the drop-indicators occupy the lowest position of the panels. This improvement, great as it was, did not meet all the difficulties. The shutters of the indicators had at first to be restored by hand after a call had been answered, every such operation causing some slight delay, which, multiplied by thousands of operations, involved much time. An arrangement was therefore designed so that the insertion of a plug into a jack, the first operation in answering a call, caused the shutter to be restored to its normal position automatically. This, however, left untouched another source of delay, that necessary to connect mentally the particular shutter that had fallen with its corresponding jack before inserting the answering plug, which, if not correctly done, resulted in the plug being inserted in the wrong jack. Again, the close of the conversation had to be indicated by the subscribers ringing off by means of their calling apparatus, an operation often forgotten by a busy, careless, or uninstructed user. If, therefore, the connection between the subscribers remained for an unreasonable time, or if another subscriber desired to speak to one of those supposed to be engaged, the operator had to come into circuit, listen for a moment, then, hearing nothing, ask: "Have you finished?" before severing the connection. To obviate all these sources of delay, the "common battery system" was designed. In this, the form of manual exchange equipment now considered the most satisfactory, the shutter indicators are replaced by glow-lamps, which, being very small, and occupying no more space than the jacks themselves, are placed immediately over the latter. When a lamp lights it indicates a call, and the operator, without doubt, hesitation, or delay, forthwith inserts the answering plug into the jack. At the subscriber's office no special calling apparatus is needed. The lifting of the telephone from the hook automatically lights the lamp. When the operator has ascertained, by touching the metallic rim outside the subscriber's jack with her connecting-plug, that the subscriber who is wanted is free, this plug is inserted, and its insertion is followed by the glowing of a supervisory lamp near the plug-seat, there being two of these to each set of cords and plugs. The operator then gives a brief ring, and when the called subscriber takes the telephone off the hook to answer, this is evidenced by the supervisory lamp being extinguished. The operator has no further concern with the connected lines until both subscribers restore their telephones; when both the supervisory lamps glow, the connection is severed, the lamps darken, and the normal condition is restored. The work of the operator is conducted with absolute certainty, no breaking in to ask questions is necessary; she knows by the glowing or extinguishing of the supervisory lamps whether the subscribers are talking or have finished, and all her speech on the line can be reduced to "Number, please," and, perhaps, "Subscriber engaged," or "Subscriber doesn't answer."

This simplicity in manipulation is, however, as might be assumed, arrived at by considerable complication of apparatus, which, if dealt with in detail, would take up a whole evening.

The electrical energy in common battery systems is, as may be inferred from the name, provided by accumulators at the exchange, instead of by primary batteries at each subscriber's office; and not only is the cost of the exchange infinitely small as compared with the old system of providing separate batteries for each subscriber, but the further advantage follows that the full energy is always maintained, and available on every circuit, a condition almost impossible to fulfill even under the best organization, when thousands of primary cells scattered over a great city have to be looked after by linemen, some of whom may do their duty less conscientiously than others, while some subscribers may exhaust their batteries by careless use quicker than should be the case.

Similar automatic arrangements are in use on the junction lines connecting the various exchanges necessary for the effective service of large cities.

In the period during which the ordinary telephone equipment has undergone the modifications just described, inventors have turned their attention to the design and perfection of an automatic telephone, in which each subscriber, by a simple method of manipulation, may, without the intervention of an operator at the exchange, obtain direct access to any other subscriber connected with the service. One of the earliest systems of this type was known as the Strowger, and by the courtesy of the Automatic Electric Company of Chicago, the owners of the patent rights, and of the British Insulator and Helsby Company, of Prescot, I am able to illustrate the working of the system. Each subscriber's line terminates on a line switch which forms part of a group of 100 switches. This switch is connected by ten circuits, the equivalent of the plugs and cords in a manual board, with a series of selectors, each accommodating 100 junction lines. According to the size of the exchange there may be two or three sets of selectors connected similarly by means of junction circuits, and, finally, there is a connector, a somewhat similar instrument, which makes the connection between the two subscribers.

Each telephone has a dial with finger-holes and numbers. On removing the telephone from the hook the procedure is as follows: If, say, No. 4,852 is wanted, the caller inserts his finger in hole 4, and revolves the dial up to the limiting stop. This actuates the line-switch, which causes a connecting-plug to enter the springs of the first disengaged junction leading to the selector group of 4,000. The same action follows in sequence with 8, 5, and 2, the final movement of the connector making the connection if the required subscriber is disengaged. If he be through to another, a busy back-signal (a vibratory current, is given. When the connection is made, and the conversation is complete, the hanging up of the telephone restores the connections to the normal. A full description of the apparatus would take up a whole evening; but its working can be inspected at the close of my address.

This method has had considerable development among the independent telephone companies in America.

TELEGRAPH AND TELEPHONE STATISTICS.

Wire Mileage.

	1902.	1907.	Increase.
Telegraphs—			
Land wires.....	3,659,659	5,038,981	1,379,322
Submarine cables	212,894	259,000	46,106= 21.6 p. c.
Telephones—			
Wire	7,467,417	19,839,537	12,372,120
Subscribers' stations	3,534,036	8,406,336	4,872,300

The Future.—On the future development of telegraphs and telephones few of those acquainted with the subject would venture to dogmatize; but certain statistics I have prepared will convey to you possibilities far more pregnant than any amount of speculation. The following figures, for the years 1902 and 1907, respectively, have been gathered from authentic returns, and they embrace information from every country of importance throughout the world.

Large figures frequently fail to impress the mind; but when it is stated that this mileage of wire will soon, if it has not by this time, equal one-third the distance from the earth to the sun, the remarkable activity of the modern telegraph and telephone service will perhaps be more forcibly realized.

It will be observed that although the development of the telephone service is taking place with giant strides, telegraphs—both land and marine—have shown remarkable growth in the intervening period of five years, notwithstanding the keen competition of the telephone. The great increase in the latter service, however, has taken place within a relatively limited period of time. In the growth of the American Bell systems the great advance commenced in 1896, when the associated companies only possessed 300,000 telephones. In 1905 this number had risen to 2,000,000, and in 1907 to 3,000,000; while at the beginning of the present year the corresponding figures were 5,100,000.

My somewhat brief and hasty generalization of the subject, necessarily limited by time, has not admitted even of reference to many subjects of interest, such as combined telegraph and telephone working on the same wires, and the use of repeaters to increase the speed of working on long lines; nor have I been able to refer to other aspects of telegraphy, such as modern fire-alarm systems, railway signaling, etc., to which the public owe much in the shape of immunity from danger and accidents; but I trust that what I have said will show that this, one of the earliest branches of electrical engineering, is not stagnant, but, on the other hand, very much alive; it is served by some of the keenest and most advanced electricians, and is absorbing annually a large amount of capital, which it is turning to good and profitable use.

Wireless Telegraphy.—The time that has necessarily been taken up in dealing with the preceding subjects has left little space for wireless telegraphy; but I am told that under no circumstances must I pass it by without mention.

The idea of telegraphing without wires goes back to the early days of telegraph working, and methods were designed, partly based on earth induction and partly on electro-magnetic induction, which admitted of communication over limited distances. Even at the present date there are two examples in the United Kingdom of this method—one a wireless-telegraph service between Rathlin Island and the North of Ireland, a distance of eight miles, and the second a wireless telephone between the Skerries Island and Holyhead, a distance of three miles. The range, however, attainable was so small that when Marconi introduced a system based on the work of Hertz and other investigators, attempts to improve the older method ceased.

It was known by Henry, after whom the unit of self-induction has been named, that the discharge of a Leyden jar, which to the eye appeared as a single spark, was really of an oscillatory character, and Hertz proved that when a powerful induction coil was connected to two conductors separated by a spark-gap, each time a spark occurred the oscillations that were set up in the conductors caused electric waves to traverse the ether. He analyzed these waves by interposing a metallic ring, provided with a microscopic spark-gap, in their path, the passage of the waves being evidenced by a spark at the gap. This detector was not fitted for telegraphic use; but the subsequent invention by Branly of a more effective detector—the coherer—paved the way for Marconi's work.

Marconi, in the first instance, connected one terminal of an induction-coil to a lofty vertical conductor, and the other terminal to earth. Each discharge across the gap resulted in electrical oscillations in the vertical conductor, and these oscillations caused electrical waves to radiate through space, as is now well known. As these waves cut across other vertical conductors, electrical currents were generated, which acted on the coherers, and signals were recorded. These waves were, however, highly damped, and practically only the first rapid rise had any material effect on the receiving apparatus, so that under these conditions all stations within range were affected by the signals. Further, as these oscillations had a frequency of the order of a million per second, and the impulses from the induction coil were of the order of ten per second, there were relatively very long intervals between each successive wave emission. The attention of all those interested was, therefore, directed toward the discovery of selective apparatus for tuning, and to effect this object endeavors were made to replace the highly damped by as near an approach to undamped waves as possible. This was partially effected by establishing an oscillating circuit consisting of a capacity and an inductance around the spark-gap of the induction-coil, so that the oscillations would be more continuous than in the first case, the vertical conductor being connected either directly or inductively with the oscillating circuit, and thus the first measure of success by selective tuned circuits was achieved. So long, however, as ordinary induction-coils with their slow make-and-break arrangements were in use, the relatively long idle period between successive oscillations still existed, and the ideal system of absolutely undamped waves remained unattained.

A further step in advance was achieved by Poulsen who replaced the spark-gap by an arc, and thus ob-

tained an enormously increased number of primary impulses, so that the emitted waves were more and more continuous, and this method has been followed by that designed by Lepel, in which the arc is replaced by two or more metal disks separated by a minute space.

By substituting a telephone transmitter for the ordinary telegraphic key, it has been found possible to transmit actual speech a distance of thirty to forty miles, while the limit of telegraphy may now be placed at, perhaps, 5,000 miles.

This very brief sketch must necessarily fail to do justice to the manifold improvements that have been introduced into all the details of working, either in spark or arc telegraphy. Each fills at present a definite sphere, and we have by no means arrived at finality in this interesting branch of the earliest type of electrical engineering.

HIGH AND LOW WATER ALARMS FOR BOILERS.*

INGENIOUS SAFETY DEVICES.

BY W. H. WAKEMAN.

FIG. 1 illustrates the first boiler that I ever had charge of, and the first low-water alarm that filled me with consternation. The former is still known as the locomotive boiler, but the latter has long since passed into oblivion, or at least into disuse, so far as general practice is concerned. This first experience was secured in 1875, and the low-water alarm was located as shown in compliance with a city ordinance, which stated that all boilers used in that city should be equipped with this safety device as a positive preventer of boiler explosion. Previous to the enactment of this law, a boiler located near the center of

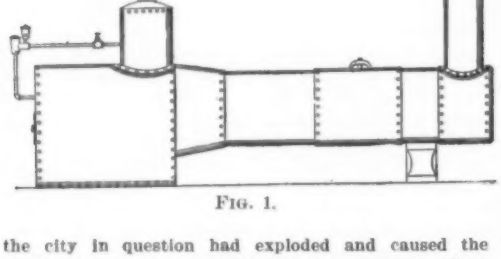


FIG. 1.

the city in question had exploded and caused the death of twenty-two persons, and the only cause given by those immediately concerned in the catastrophe, and believed by the general public, was lack of water sufficient to cover the plates exposed to the action of heat.

When viewed in the light of our present knowledge of the subject, it seems at least strange that anybody could believe that there was only one cause for boiler explosions, but for several years after this first experience I heard no other cause mentioned, and it was by reports published by the Hartford Steam Boiler Inspection and Insurance Company that the many real causes for these destructive failures were made plain.

I very naturally supposed that if the neglect of one man caused the loss of so many lives and the destruction of thousands of dollars worth of property, he would at least be discharged in disgrace, and never allowed to have charge of a steam boiler again; hence I was greatly surprised to find that the engineer in charge of the exploded boiler, who was also the fireman and water tender, was still in charge of the machinery in that plant after the wreckage was cleared

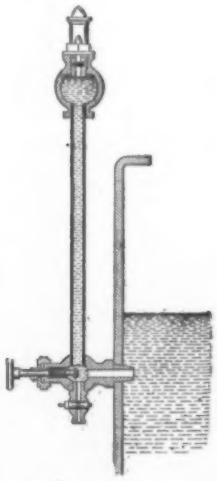


FIG. 2.

away and a new boiler set. The reason given by the owner for this action was that nobody could have prevented what they called an accident, hence their engineer was not to blame. This was not due to any particular regard for the engineer or his abilities, but to save the expenses of paying damages to the relatives and dependents of those who were killed, and directly to those who were injured.

The main part of this low-water alarm is attached to the front head about 3 inches above the crown sheet, for a small boiler, while a smaller pipe is tapped into the dome, in order to secure dry steam. A power pump was installed for the purpose of drawing water from a driven well and forcing it into this boiler, but it was almost impossible to bring water up to this pump because the strainer offered much resistance to the flow of water, and pressure of the atmosphere cannot act directly on the surface of water outside of such a well and thus force it up into the pipe. This pump was driven by a pulley on the crank shaft, and it was customary to remove the governor belt and run the engine as fast as was safe, until water appeared at the pump, after which the governor belt was replaced and water was assured for the remainder of that day.

When this boiler was installed, it was filled with water to the second gage by hand, a fire was built in the furnace, and efforts made to secure water by the pump, which were not successful the first day. While we were working on the pump the water level was lowered until it left the front-head connection uncovered. Steam was thus allowed to enter this pipe and passing upward melted the soft metal with which the head of the device was filled. This action released the whistle valve and in an instant a shrill blast startled all who were near. Somebody opened the safety valve, and somebody else drew out the fire in record time. Of course, the safety valve ought not to have been opened, but our experience was limited at that time. As the metal which prevented the whistle from blowing under normal conditions was gone, it was necessary to remove the device and have it repaired before it could be used again. The objection to this was the delay caused, and the expense incurred. On the other hand, it was a valuable feature, because it assisted materially in causing us to be more careful. However, as no more boilers exploded, the excitement subsided, the ordinance was repealed, and the use of high and low-water alarms is now optional with all steam users in that city.

Fig. 2 illustrates a similar device except that only one connection is required, and an angle valve is provided for shutting off the alarm whenever it needs repairs. The objection to the presence of this valve is that it may be shut when it ought to be open, hence the fireman or water tender may allow the water level to fall lower than it ought to, and no alarm will be given. However, it should be considered a necessity, and suitable measures taken to prevent unauthorized persons from meddling with it. If a water tender closes it to prevent an alarm from being given on account of carelessness and neglect of duty on his

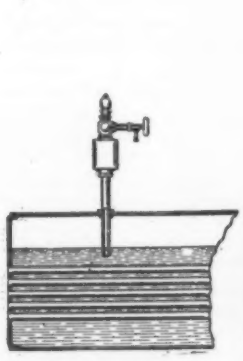


FIG. 3.

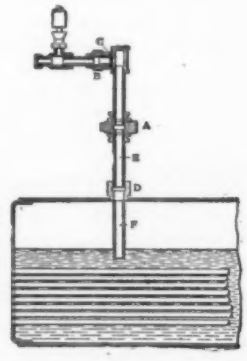


FIG. 4.

part, he should be reprimanded, and if the offense is repeated he ought to be discharged.

This low-water alarm operates as follows: As long as the inlet is covered by water, the vertical pipe remains cool, as there is no circulation through it, but if the water level falls low enough to uncover the inlet, steam enters the pipe and, ascending to the top, melts the soft-metal plug which covers the whistle inlet, as it is made of an alloy that melts at 212 deg. F. Having melted the plug, steam blows freely through the whistle, giving an alarm with no uncertain sound.

In order to restore normal conditions, shut the angle valve to stop the noise, and open the drip cock to let

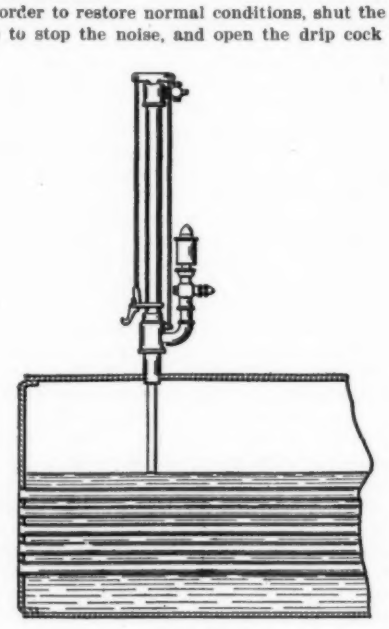


FIG. 5.

out the water standing in the pipe. Pump water into the boiler until the alarm-pipe inlet is covered, and do it without delay, for although the front-head connection shown is, or ought to be, set high enough to blow the whistle before the upper tubes in a tubular boiler or the crown sheet of a locomotive boiler are damaged by heat, or are liable to be warped by the introduction of more water, still the water level will soon become too low for safety, especially as the alarm is sure to distract attention from everything else.

Unscrew the whistle, put in another plug, screw the whistle down hard on it to make a tight joint, then admit water to pipe slowly (after closing the drip

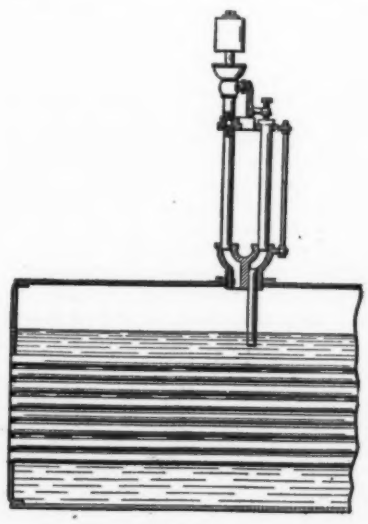


FIG. 6.

cock), for unless this is done cautiously the new plug will be melted by heat, because the temperature of water in an ordinary boiler used for power purposes is much above 212 deg. This alarm can be attached to the shell of a vertical boiler, where it will be equally effective.

The following alloy will melt at about 212 deg. F.: Lead, 1 part; tin, 3 parts; bismuth, 5 parts. It is claimed that any alloy of which bismuth forms a

* Power and the Engineer.

part is not reliable for this service, because it will not retain its original nature indefinitely, hence will fail to melt when it ought to. It is quite possible that this refers to regular fusible plugs as used in steam boilers, as they are exposed to very hot water on one side, and the temperature of a fire on the other, hence pure Banca tin is recommended for them; but this metal is useless for the low-water alarms illustrated in this article, because it requires a temperature

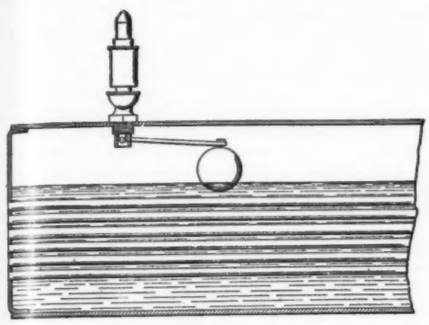


FIG. 7.

of 445 deg. to melt or fuse it. Of course these fusible plugs are exposed to a much higher temperature on one side only, as the pressure of steam must be raised to 400 pounds absolute in order to secure this temperature, and that is seldom or never realized, even in these days of high pressure. The fire does not melt them because heat passes rapidly into the water, but steam at the same temperature has a very different effect, causing the plugs to melt.

Fig. 3 illustrates another device for giving an alarm when the water level is approaching the danger line. It is attached to the shell, but projects down through it far enough to submerge the lower end when the water level is right for working conditions, but when it falls to a depth of about 4 inches over the upper tubes, or flues, as the case may be, steam enters the vertical pipe and, melting a soft-metal plug in the body of the device, causes the whistle to blow.

When this happens, shut the valve, pump in more water, remove the whistle, put in another plug, replace the whistle and open the valve slowly. Care must be taken to make tight joints, for even a slight leak will cause a circulation that may raise the temperature high enough to melt the new plug when there is plenty of water in the boiler.

Superficial examination of this device, in connection with the knowledge that water and steam in a boiler are of the same temperature, will cause a fireman to wonder why the alarm operates as described. This point is made clear when he remembers that under working conditions water will not circulate through this vertical pipe, but will go up into it and stay there until it becomes comparatively cool, provided every joint is absolutely tight. If the water level falls low enough to allow steam to enter the end of this pipe, conditions are at once changed. The full temperature due to the pressure carried is transmitted to the plug, and when condensation due to radiation results in the appearance of water at this point, it runs back into the boiler and is replaced by more steam until the plug melts.

On a certain occasion I stated that water and steam in a boiler were of the same temperature (as herein mentioned), and was promptly corrected by a listener, who stated that he pumped cold water into his boiler and the plates around the feed pipe where it was tapped into the boiler were cool, hence water could

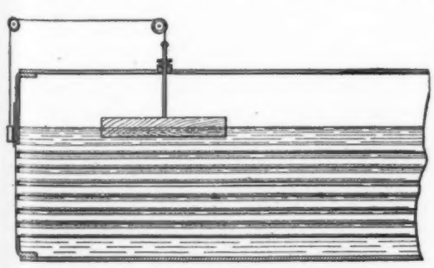


FIG. 8.

not be as hot under these conditions as the steam above it. So far as his limited comprehension of the subject would admit, he was correct, but in all such cases it is expected that common sense will be used and intelligently applied. Of course it is generally understood that when the foregoing statement is made it refers to water that has been in a boiler long enough to attain its highest possible temperature; also, that the boiler is designed so that circulation is at least nearly perfect. Although water has the same temperature under these conditions, it does not flash into steam, because it lacks the latent heat required by the process of generating steam.

Fig. 4 illustrates another low-water alarm in which a soft-metal plug is an important feature. It is attached to the shell and extends down through it to the low-water level, wherever that may be. While this depends on the judgment of the engineer in charge, after taking all conditions into consideration, there are few cases in which the water should be less than 4 inches deep over the tubes of a tubular boiler, or the crown sheet of the locomotive type, when the whistle blows, and 6 inches is better in many cases.

When the whistle in Fig. 4 blows for low water, the plug cock *A* must be closed and more water pumped into the boiler. Unscrew the cap *B*, remove what remains of the plug *C*, insert a new one, screw on the cap until it is firmly seated, and open *A* slowly. If a globe valve is used here, there will be less danger of its sticking fast when it ought to work freely, and it can be repaired with little trouble and small expense.

A special bushing is shown at *D*, into one end of which the pipe *E* is connected, while *F* is screwed into the opposite end, leaving a small space between them. Care should be taken when making up such a fitting to know that the pipes enter far enough to secure a firm hold, also that there is an open space between them as illustrated. The shells of many boilers are only ⅝ inch thick, while some are less; therefore, a first-class job cannot be secured by screwing in the bushing from the outside, as there are not enough threads available. By starting the tap from the outside, and finishing it from the inside, it is practicable to insert the bushing from the inside and thus prevent it from blowing out, even if the threads are corroded by long service until they no longer are strong enough to resist the pressure put upon them.

An objection to all kinds of low-water alarms which depend on the melting of a plug for their operation is that they cannot be tested in service, therefore it is impossible to know their true condition. Of course

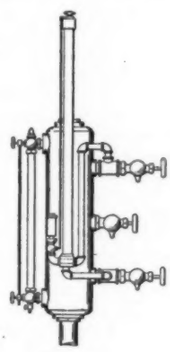


FIG. 9.

it is possible to let the water level fall until the whistle does, or ought to, blow, and observe the result, but in either case it becomes necessary to insert a new plug that has not been tried, thus restoring the uncertain element. The following plan is recommended for such cases: Secure a dozen plugs made from the same alloy. Insert one and test it by lowering the water level until steam enters the pipe. If the plug melts promptly, it is good evidence that they are reliable under given conditions for one year, hence a new one should be inserted annually. The time may be shortened if greater safety is demanded.

Fig. 5 illustrates a device for blowing a whistle when the water level falls too low for safety, the operation of which is based on the principle that brass and iron do not expand equally when heat is applied. Under normal conditions the lower end of the vertical pipe is submerged in water. As soon as the water level is lowered until it begins to assums the position shown in the illustration, all water runs out of the pipe and is replaced by steam, but it is not admitted to the whistle by this action. The temperature of the pipe, which is made of brass, is raised and it is lengthened accordingly.

The rods on either side of the pipe are made of iron, but inasmuch as the coefficient of expansion for brass is about 50 per cent greater than for iron, the pipe expands more than the rods for an equal rise in temperature, and it is quite possible that the latter are not as hot as the former while in service, because steam does not come into direct contact with them, hence the actual difference in expansion is greater than the foregoing implies.

As the rods are anchored at their lower ends, the difference in length causes the whistle to open and admit dry steam from the upper part of the steam space, thus giving the alarm in time to prevent damage from low water. When the usual water level is restored water fills the pipe, again causing it to contract and close the whistle valve. This alarm can be tested by opening the pet cock shown at the top and allowing hot water to circulate through the pipe, thus raising its temperature the same as if steam were admitted to it, without lowering the water level.

In case the whistle does not blow when this test is applied, the rods should be shortened by nuts provided for this purpose, until the valve is barely open. If the whistle continues to blow after the standpipe

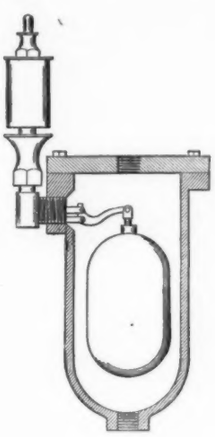


FIG. 10.

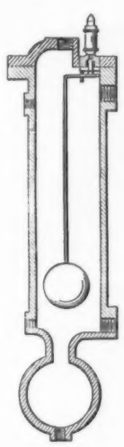


FIG. 11.

becomes cool, the rods must be lengthened by adjusting the nuts in the opposite direction.

Fig. 6 illustrates another low-water alarm which is operated by the expansion of a brass pipe, but the claim that is plainly made for it to the effect that it depends on the difference in the expansion of the two metals is apparently not warranted. The claim is as follows: The left-hand vertical pipe is made of wrought iron, and as it is connected directly into the steam space of the boiler, it is always full of dry steam up to the valve just below the whistle. The right-hand pipe extends down below the normal water level, hence is filled with water under working conditions and usually is comparatively cool because there is no circulation through it, as it forms what is known in hydraulic work as a "dead end."

This pipe is made of brass and terminates in a cap on which rests an adjustable screw carried by the outer end of a bell-crank lever. The upper end of this lever rests against the stem of the whistle valve, and the screw is adjusted so that when the pipe below it is cool, the lever touches the whistle valve lightly. When this pipe is heated by steam on account of lowering the water level, it expands, raises the horizontal end of the lever, causing the vertical end to open the whistle valve and sound an alarm that continues until the water level is raised, as no valve is provided for shutting it off by hand.

This alarm can be adjusted while pressure is on the boiler, hence the left-hand pipe is then as hot as steam can make it; consequently, it makes no difference whether it is made of iron or brass, because its length when expanded becomes the standard regardless of the amount of expansion. The right-hand pipe must be filled with cool water when the adjustment is made, and as soon as it is expanded by steam the whistle

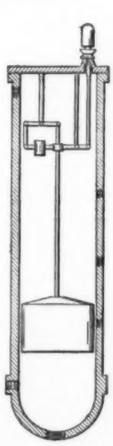


FIG. 12.

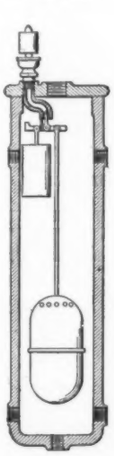


FIG. 13.

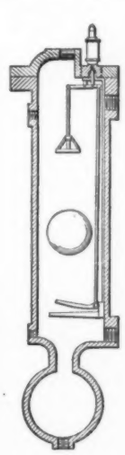


FIG. 14.

blows (if a correct adjustment has been made) regardless of the length of the left-hand pipe, hence it is plain that the difference in expansion has no bearing on the device or its operation. A reinforcing ring is riveted to the shell in order to afford a more secure fastening for the alarm, and this is worthy of adoption in all such cases.

One advantage of low-water alarms operated by the

expansion of metal is that they can be tested at any time and their condition proved beyond dispute. The only disadvantage is that they require a fine adjustment, which is too difficult a task for the ordinary fireman or water tender to complete and maintain; but, on the other hand, there seems to be no good reason why the engineer should not attend to this exclusively, and thus avoid all trouble along this line.

The low-water alarm illustrated in Fig. 7 consists of a whistle screwed into the shell, containing a lever valve operated by a float which rises and falls with the water level. This arrangement will undoubtedly work well as long as the float remains in good order, but unless it is of superior design and made in a more workmanlike manner than many of those found in service, it will prove a source of more worry and vexation than of comfort.

A dishonest boiler attendant cannot tamper with this low-water alarm while it is in service, as the float is in a secure place, and there is no globe valve on the outside to close, in order to prevent exposure of carelessness in allowing the water level to fall too low for safety.

The disadvantages of this device are that if the float collapses or fills with water and sinks while there is still plenty of water in the boiler, the whistle will blow and no legitimate way of stopping it is provided. Such defects, or a failure of the lever mechanism, cannot be repaired easily, as the boiler must be laid off for this purpose, and if this is not practicable, the low-water alarm must be dispensed with until an opportunity arrives for entering the boiler and making necessary repairs.

Fig. 8 shows what may be called a "home-made" low-water indicator. It consists of a block of wood floating on the water to which is attached a brass rod carried through a stuffing box in the shell. A stout cord or an annealed wire is carried from this over two pulleys and supports a weight suspended in front of a dial, and the position of this weight indicates the water level. This device was described to me by an English engineer who had used it.

Fig. 9 illustrates a low-water alarm that is not attached directly to the boiler but to the water column. The lower connection is made by removing the first gage cock and screwing in a close nipple followed by a tee, the outer end of which receives the gage cock for use as before. Into the side outlet of this tee a close nipple is screwed, followed by an ell and other connections as shown. The upper connection is made by removing the third gage cock and proceeding as before, using brass pipe and fittings because they rust and corrode less than iron.

While there is one gage, or more, of water in the boiler, the standpipe remains full of comparatively cool water, but when the water level falls until there is only about one inch left in the glass, steam enters the standpipe and as it is made of copper it lengthens, thus opening the whistle valve by means of the rod shown, and admitting steam from the third gage cock through a cross passage to the whistle, although water comes first, as a small amount always stands in the vertical pipe which stands parallel to the standpipe.

Fig. 10 is an independent water column to be used as a low-water alarm. It contains a steel float to secure the required strength and it is coated with copper to prevent corrosion. A water gage and three gage cocks can be tapped into this column if desired. It is a very simple device, for as long as there is water enough to keep the float in its highest position, the whistle is silent, but when it falls and lowers the float, the alarm is given with no uncertain sound. It can be tested at any time by opening the drip valve.

The whistle and the float are connected to the body of the water column, hence when repairs are necessary the cap screws shown are removed and a union in the pipe below is disconnected, thus leaving the column free to be moved sidewise and taken down. The same packing can be used several times if one side of it is coated with graphite. After repairs are completed the column can be returned without disturbing the piping. The cap of this column is flat, therefore any ordinary wrench can be used to tighten the cap screws without inconvenience, which is a valuable feature. Special care should be taken when installing this or any other water column to set it high enough to give an alarm when there is at least 4 inches above the tubes, flues or crown sheet.

Fig. 11 resembles the preceding, but is much longer, hence is suitable for boilers in which the water level may vary to a greater extent without causing damage, as the extreme length of this column is nearly 5 feet. The float is in the form of a sphere, which is the strongest that can be devised. In this case the whistle and its controlling mechanism are attached to the cap, hence when this is removed all the working parts come out with it. This is a very convenient plan when it is practicable to run the pipe connection directly into the body, as shown by the larger tapped holes, but there are many cases in which it is better to make connections into the top and bottom, thus making it impossible to lift the cap out as described, unless a union is used in the piping, which would otherwise be unnecessary.

Fig. 12 illustrates another low-water alarm in which the controlling mechanism is attached to the cap. This does not include a float, hence there is no danger of its collapsing or filling with water. One large gravity weight on the end of a rod and a small solid weight on one of the compound levers operate to open and close the whistle valve, according to the height of water in the boiler and hence in the column. When there are two gages of water, the larger weight so nearly floats that the small one is sufficient to counterbalance it and keep the whistle valve closed, but when the water level falls, leaving one free, it opens the whistle valve and sounds an alarm.

Fig. 13 is similar to the foregoing, but the compound levers are dispensed with, and only one used instead, consequently the upper solid weight is larger, but the device is simple and not liable to get out of order.

Many boilers have been seriously damaged, some of them beyond repair, by allowing water to get low in them with a brisk fire in the furnace, and others have suffered from the effects of fire under them before they were filled at all, yet only a comparatively few explosions have occurred directly from this cause, and there is no mystery about any of them. If a plate or a crown sheet is red hot from lack of water, its original strength is greatly reduced, hence the ordinary working pressure may cause it to fail, and it may not have sufficient strength to destroy much property, for it is plain that a weak boiler will rupture before a high pressure can be secured, hence the resulting damage will be light.

Furthermore, the overheated part may fail just as more water is pumped in, but it is doubtful if the entrance of water into an overheated boiler has ever caused the instantaneous increase of pressure with which it is charged, or resulted in the formation of a mysterious gas that could not be controlled. Experiments that have been made under working conditions to prove the truth of claims made for the aforementioned destructive agents have failed to show that we are in danger from them.

There can be no doubt about the truth of claims made for excessive repair bills, damaged boilers and expensive delays to business caused by failures to keep boilers properly supplied with water, and these are sufficient to warrant every precaution that can be taken to prevent such accidents without causing them to appear mysterious, or uncontrollable. The variety of low-water alarms already described and illustrated in these pages, and the large numbers of them sold and put into service on various kinds of boilers, furnish proof of their need and value.

Previous illustrations are of devices that guard against low water only, but very expensive accidents have happened on account of high water in boilers, because under such conditions there is danger of delivering hot water to the engine instead of steam, and as they are not built for such abuse the weakest parts must fail, and although such accidents seldom result in loss of life, they destroy valuable machinery and cause delays to business.

Fig. 14 illustrates a water column fitted with an alarm for both high and low water, which operates as follows: A spherical, seamless float without means for attaching a lever or rod to it is put into the column, which is then partly filled with water to secure working conditions. The float stays on the surface or is only partly submerged, bringing it into the position shown. The upper weight is sufficient to keep the whistle valve closed, but if the water level is raised higher than good practice admits, the float comes in contact with the upper weight, raises it and blows the whistle. If the supply of water to the boiler is shut off and the process of evaporation is continued, the float is lowered with the water level until it rests on the lower lever shown, and this action blows the whistle. As the float is not fastened to anything, it is free to turn in every direction, hence it cannot wear excessively in one place; therefore, it proves durable in practice. All of the mechanism is fastened to the cap, hence when this is removed the internal parts come out with it.

THE USE OF CELLULOID IN MICROSCOPY.

IN making micro-chemical analysis, says Prof. Sommerfeld in Die Gummi-Industrie, it is often necessary to use fluoric acid, fluorammonium and other substances which attack glass; the object plates are thereby rendered "matt," like ordinary ground glass, so that it is desirable to use, instead of glass, some other material which is not so attacked—and of these celluloid is the best. There is another reason for this, that the reagents which attack glass are often used to show micro-chemically the presence of elements which are present in glass, as for instance soda, potash, or lime. In such cases, glass is impossible to be used, as when it is in the least attacked by a reagent, the chemist is uncertain whether the soda, potash or lime comes from the material being tested, or from the glass. Celluloid is suited to such work by reason of its resistance to reagents; but cannot be used in such cases, when alkaline reagents are used, as these attack celluloid. In such cases, therefore, glass must be used.

A second advantage in the use of celluloid in microscopy is as follows: For many purposes it is desirable to have object plates which are perforated like a sieve; this is more readily attained with celluloid than with glass. The perforated plates are very desirable in many cases of measurements of thin sections in microscopy and photography. The thickness of the thin sections cannot be measured with the desired accuracy when below the sections to be measured or even over them glass or other transparent material is cemented. But for mineral sections, even in very limited areas not covered or underlaid by the transparent plate, accurate optical interference methods may be employed to determine the thickness.

If there is only one mineral to be measured, one hole in the object plate would be enough; but often there are several places in the section to be measured, as in petrography, there is usually a number of very minute crystals, so that the advantage of a perforated object plate is apparent, and this is possible only with celluloid.

Incidentally, it may be remarked that mica or gypsum, which the layman might consider as suitable for such purposes, is perfectly useless for mineralogical or micro-chemical work; for this one can use only amorphous materials; as crystalline substances, such as mica and gypsum, counteract the interference tests shown by polarized light.

The employment of sieve-like perforated plates is also to be recommended for micro-chemical analysis. In making permanent preparation, the precipitates which are formed at once by the addition of the reagent, must often be cemented by Canada balsam or similar material between the two glass plates of the slide. The watery solution from which the characteristic precipitate has been formed must be removed; but this may not be effected by evaporation, as the soluble salts in the solution would crystallize and cover the precipitate. It is, however, very easy to remove the solution when the slide is perforated. At first one must place thereunder a non-perforated slide; and when the precipitate is formed this is to be carefully removed; which will permit the greater part of the solution to drop through, taking with it, it is true, a very slight portion of the precipitate; but enough will remain for all practical purposes.

It may further be mentioned that celluloid is, in many cases, cheaper than glass for slide-covers; and that it has only one quality which acts against its use in microscopy—its former habit of getting cloudy—which nowadays is seldom the case. If it were possible to make a perfectly incombustible celluloid—which many an inventor has considered that he has produced—this material would have in microscopy the further advantage, that it would permit cementing the object to it by heating Canada balsam. At present, however, where celluloid is to be used, one must either use a solution of this material or employ another substance.

As yet, the employment, of celluloid for lenses is not successful.

"MITOKINETISM."

AT a joint meeting of the Botany and Zoology sections of the British Association for the Advancement of Science, Prof. M. Hartog described "Mitokinetism, the new force." His paper was welcomed heartily as an interesting and valuable contribution to the Conference. Prof. Hartog explained that by a new force he meant one of which the character and distinctness had only newly been recognized. The force was discovered in 1873 or thereabouts; but its distinctness was only finally demonstrated by the observations of Pentimalli in 1909 and the author's own interpretation of these results in the present year. When the cell divides, a curious figure is formed, like a spindle with (in animals) a sphere at either end, from which rays diverge outward. The inner rays are concave to the axis of the spindle, a point which is very important. Such a figure can only be produced by a force whose intensity decreases as the square of the distance (a Newtonian force), and one which has two opposite manifestations, such as source and sink, heat source and refrigerator, positive and negative (electrostatic), north and south (magnetic). Such forces are called "dual forces." Prof. Hartog showed that none of the recognized dual forces could be invoked, and that the name "Mitokinetism," which he had given some years ago to avoid any prejudgment of its nature, must now be accepted as that of a new force, unknown outside the living organism.

THE STUDY OF SOLUTIONS.—II.*

PAST THEORIES AND FUTURE RESEARCH.

BY DR. LOUIS KAHLENBERG.

Concluded from Supplement No. 1817, page 288.

IN the study of the various physical properties of solutions with changing temperature and changing concentration, it has been absolutely demonstrated that different solutions behave quite differently, and that solutions of compounds that are chemically analogous show an analogous, but by no means an identical, behavior. It is consequently quite impossible to write an equation that will hold for the various known solutions—not even approximately. Attempts to formulate an equation for a so-called perfect or ideal solution are about as successful as an attempt to write an equation for an ideal or perfect chemical compound would be. In short, such equations are necessarily based upon postulates that are not in accord with experimental facts, and consequently the equations themselves can not and do not agree with what is actually observed. The attempts to parallel solutions with gases in a quantitative way would naturally suggest that there might be an equation for an ideal or perfect solution, just as we are wont to write an equation for a so-called ideal gas, but the suggestion is quite misleading, just as all of the efforts at a quantitative study of solutions based upon gas analogies have proved futile. This is true not only of solutions of moderate concentration, but of dilute solutions as well, as a careful unbiased scrutiny of the numerous experimental data that have been collected shows.

The act of solution is accompanied by all of the phenomena that are observed in the case of changes that are regarded as chemical by common consent, and this shows that solutions are chemical in character. We commonly say that whenever substances combine chemically with each other, the new substance formed has properties that are quite different from those possessed by the original substances. While this is true, it is also the case that some of the properties are not changed at all, while others are but slightly modified, and still others are very greatly altered indeed. So, for instance, the weight remains unchanged during chemical action; the specific heat is frequently altered but little, whereas the color, volume, and other properties, may be very greatly affected. In general, we may say that *when an element or compound enters into combination with other elements or compounds, each of the ingredients of the new substance formed tends to retain its original characteristics as far as the new conditions to which it has been subjected permit.* In reality every chemist is well aware of this, though as far as I know the idea has never before been stated in so many words. The degree to which an element loses its original properties on entering into combination with other elements depends very largely upon whether the chemical change involved is a drastic or a mild one, which, in turn is principally determined by the energy accompaniments of the reaction. In the study of solutions, which in general represent rather compounds formed by relatively mild changes as compared with many of the stereotyped chemical reactions, the thought just expressed is particularly helpful. So, for instance, sodium has a great affinity for the elements of water, upon which the solubility of sodium compounds in water largely depends. On the other hand, sodium is inert toward hydrocarbons, which fact is at the basis of the insolubility of sodium salts in hydrocarbons. An element with pronounced chemical characteristics like sodium, for example, will retain to a high degree its chemical predilections even after it has entered into combination with other elements. Thus, if we take sodium oleate, in which the metal is combined with the large fatty oleic radical, we nevertheless find that this soap dissolves in water. Here again the great affinity of sodium for water manifests itself, and though the metal is chained to the fatty radical which of itself exhibits no inclination to unite with water, yet this radical is dragged along into solution, as it were, by the great chemical attraction which sodium still has for water. But the combination which water and sodium oleate form is after all but a loose one, as one would naturally expect from what has been stated. The fact that a solution of sodium oleate boils but slightly higher than pure water shows that there is but little affinity between water and the soap. Again, the insolubility of sodium oleate in hydrocarbons shows that the oleic radical, though it is known to have affinity for hydrocarbons and fats, is yet unable to drag the sodium with it into solution. On the other hand, however, the affinity of the oleic radical for fatty substances does manifest itself when a strong aqueous soap solution is brought in contact with greasy matter on clothes, etc., for by virtue of this affinity the grease is loosened from the fabrics, and though not dissolved, it is nevertheless emulsified so that it can be removed mechanically with the soap solution. Numerous other examples illustrating the principles stated might here be mentioned. I am at present engaged in the work of collecting these. Before the advent of the physical theories of solutions considerable work was done in ascertaining the chemical relationships that must exist between solvent and solute in order that solution may take place; but during the last two decades this work has been practically discontinued, which is particularly unfortunate. It clearly indicates, however, how our so-called modern conceptions of solutions, which have been pressed upon the scientific public by a species of propagandism that is, and it is to be hoped will remain, quite unrivaled in the history of chemistry, have really stood in the way of progress.

In some quarters the idea is still prevalent that electrolytes are essentially different from non-electrolytes in their chemical behavior. This is thoroughly fallacious, for *all chemical changes that occur in electrolytes can now be reproduced as to type and as to rapidity in the best of insulators. An electrolytic solution behaves like any other solution, except that it has the property of conducting electricity with concomitant chemical decomposition.* There is no way known at present by which any one can foretell whether a given solution will conduct the current or not. The only way to find out is by actual trial with the electric current itself. There is also a misapprehension that only electrolytes will cause the coagulation of colloids. Such coagulation can be quite as well accomplished by non-electrolytes, so that here too there is no essential difference between electrolytes and non-electrolytes. Upon what electrolytic conduction really depends we are still quite ignorant, just as we do not know why a bar of silver conducts and a stick of sulphur insulates. But upon this matter I have already expressed myself more fully on other occasions.

Again it is necessary to call attention to the fact that there is really no essential difference between colloidal solutions and solutions of crystalline substances. I do not refer to those so-called colloidal solutions which from the very mode of their preparation must be regarded as suspensions, which view has also been confirmed by the use of the ultramicroscope. *We are now able to separate crystalline bodies from each other by dialysis, also crystalline bodies from those that have never been obtained in the crystalline state by having the latter pass through the septum and the crystalloids remain behind; and indeed, even two colloids may be separated from each other by dialysis,* as I have demonstrated experimentally in the course of my researches on osmosis. The matter depends entirely upon the nature of the solutions and the chemical nature of the septum, and from a knowledge of these, what will happen may be foretold.

Water is a great solvent, and because of its abundance and importance to all life on the globe aqueous solutions will ever be studied with the greatest interest. But in obtaining a correct conception of the nature of solutions, aqueous solutions obviously can have no stronger vote than solutions in less abundant and far less readily procurable liquids. Water has a high cohesion, as is shown by its high surface tension and high latent heat of vaporization. The hydroxyl group which is characteristic of the water molecule certainly exhibits great tendency to cling to other hydroxyl groups. So, for instance, though hydrocarbons are not soluble in water, they become soluble when one of their hydrogen atoms is replaced by hydroxyl, provided that the number of carbon atoms in the compound is small. However, when more than one hydroxyl group is in an organic compound, the latter may have even a relatively high carbon content and yet be soluble in water. A study of organic hydroxyl derivatives shows that compounds consisting of carbon, hydrogen, and oxygen, and containing one or more hydroxyl groups for every carbon atom present, are soluble in water, though, to be sure, even considerably less than one hydroxyl group per each atom of carbon in the molecule is frequently sufficient to cause solubility. On the other hand, the multiplication of hydroxyl groups in such compounds tends to diminish their solubility in hydrocarbons. From this and similar illustrations that might readily be given, it is clear that a study of the solubility of a compound in different solvents may well serve as a means to investigate the nature of that compound.

It need not be feared that by accepting the chemical view of solutions we should lose the advantage of the molecular weight determinations by the boiling-point and freezing-point methods. These methods would serve us as well as ever. But we should not argue that common salt is dissociated in water because a gram molecule of it added to a liter of water produces a solution that has a higher boiling point than the solution obtained by adding a gram molecule of sugar to a liter of water. We should rather hold that the higher boiling point of the former solution is due to the greater affinity between salt and water as compared with that between sugar and water.

The study of solutions then was begun with the chemical conception of solutions, and upon this conception many relationships have been worked out during the first eighty-seven years of the nineteenth century. The older chemists clearly recognized that whether solution will take place or not in a given case is first of all determined by the chemical nature of the substances brought into contact with each other. They saw that the temperature factor was next in importance, and that pressure was of vital consequence when a gas was under consideration, but of slight importance in the case of solids and liquids. When the conception that solutions are mere physical mixtures came to the foreground, through the introduction of gas analogies and the intense propagandism of the dilute school, the fact that the act of solution is really chemical in character was lost sight of by many able, enthusiastic young investigators. In the ardor of their quest they were misled, and unwittingly they naturally misled others. It is really pitiable to see how our physiologists, having thus taken up these misconceptions of the nature of solutions, are still wasting precious time in endeavoring to work out the complicated and very important processes that occur in living plants and animals. In these problems, which are in reality perhaps the very greatest that confront us at the present day, theories of solutions based on gas analogies are of no avail. They are thoroughly misleading and worse than worthless here.

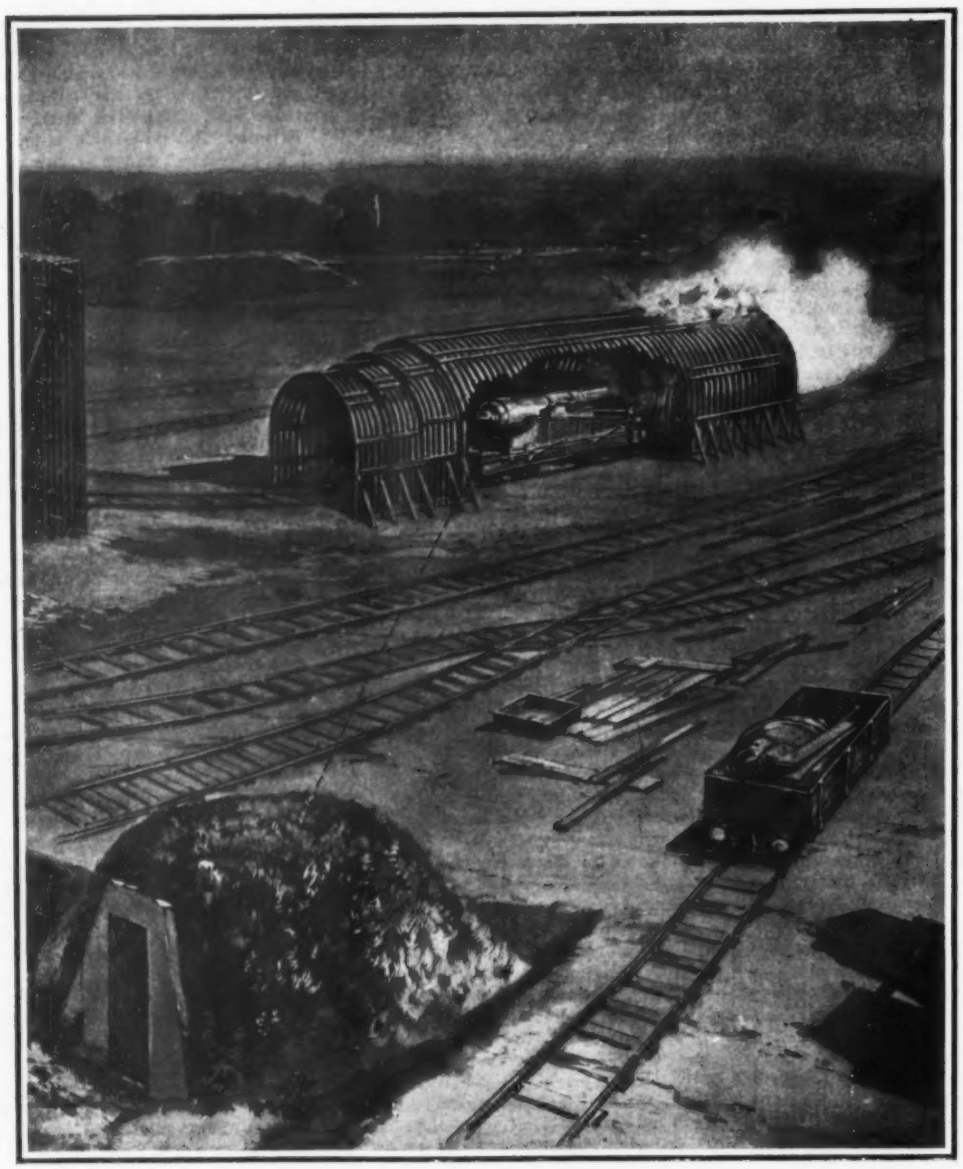
The clear recognition that solutions are really chemical in character and that there is no wide gulf that separates the act of solution from other chemical phenomena, will do much toward furthering the future study of the subject. I do not claim to have prophetic ability, but nevertheless I venture to express it as my conviction, based upon years of experimental study of the chemical, physical and physiological properties of a long list of both aqueous and non-aqueous solutions, that the act of solution is chemical, that solutions are chemical combinations, and that we can only make real progress toward a better understanding of the various solutions by recognizing this as the basis of all of our future work. The efforts to gain a better insight into the different solutions that confront us must be chiefly experimental, rather than mathematical; for in the study of solutions, just as in the study of chemical compounds in the narrower sense of the word, we are continually confronted with discontinuities. Now discontinuous functions can not be handled mathematically at present, not even by the greatest of our mathematicians, for though work of this kind has been begun, it is still in a very rudimentary stage. It is highly probable too that the renewed study of solutions from the chemical point of view will greatly aid us in getting a broader and more correct conception of the nature of chemical action itself. Certainly in living beings we have numerous, fundamental and deep-seated chemical changes going on continually with apparently the greatest ease at ordinary temperatures and pressures, and it is tantalizing that we are unable to comprehend how this is all brought about. In the unraveling of the questions that here confront us a clear recognition that solutions are chemical in nature will be of greatest service.

* Address of the vice-president and chairman of Section C—Chemistry—American Association for the Advancement of Science.

THE TESTING OF A BIG GUN.

"CAGED" IN CASE OF BURSTING.

OUR illustration gives a good idea of the method by which the security of ordnance is tested. Before a gun is made, great precautions are taken to test the steel, and the greatest care is exercised to make observations during its manufacture. But by far the most important is the final test after its completion. After leaving the factory, the gun is handed to independent inspectors. It is placed on a "sleigh" consisting of a recoil mounting on a heavy frame placed on two bogies. This sleigh is run under the cage, which is constructed of heavy railway metals in six layers, spaced by similar rails. This cage is strong enough to prevent any fragments from flying out laterally. To prevent pieces from being thrown to the rear of the gun, there is a screen at the top of a slope. Up this slope the sleigh is allowed to recoil after firing, in order to avoid straining it. Thereon it soon comes to a rest owing to its huge weight, and by a system of brakes it is so arranged that it returns to the same place where the gun was fired, ready for the next test. The gun is subjected to a charge giving a pressure of 25 per cent in excess of that of the service charge, and is fired electrically from the bomb-proof shelter shown in the left-hand foreground of our drawing. The projectile used, which is flat-headed, is fired into a sand-butt in front of the cage. The dotted line in the drawing shows the line of the electric wiring, and a section of the cage has been cut out by our artist to enable the position of the gun to be easily seen. The actual test consists in the firing of a series of gradually increasing charges, commencing with that to be used when the gun goes into use. The "service charge" it is called, the increase being adjusted so as to give finally, as already mentioned, an increase of 25 per cent on the pressures given by the "service charge." Should there be any weak portion of the gun, the severity of the extra pressures to which, in succession, the gun is subjected will find it out, and the cage is the provision made in case of such a mishap, to prevent the fragments being scattered to the general danger.—The Illustrated London News.



Illustrated London News.

PUT TO A SEVERE STRAIN. THE METHOD OF ASCERTAINING ANY PECULIARITIES IN THE GUN WHICH MAY BE A SOURCE OF DANGER.

Before the British Association for the Advancement of Science, Prof. W. Ripper, D.Eng., M.Inst.C.E., claimed that a great deal of testing of lathe cutting-tools has been done in the past by various experimenters, and is being done every day by steel manufacturers for their own information, but there is unfortunately an entire absence of uniformity of standard in the making of these tests. There are two methods of testing most commonly adopted. The first is to find the length of time the tool will run in the lathe under a given set of constant conditions before requiring regrinding; the second is to find the cutting speed which shall cause the edge of the tool to be completely ruined in twenty minutes.

Tests representing prolonged durability are of doubtful value. It is more to the purpose to know the highest cutting speed which may be maintained during some practical period of time—say, 20 or 30 minutes—without regrinding. Mr. Taylor recommends that in the case of the twenty minutes' test about eight tools of each kind should be prepared—say, 1⅛ by 1¾ and about 18 inches long—treated and shaped in every way alike. They should then be run one tool after another each for a period of twenty minutes, and each at a little faster cutting speed than its predecessor, until the cutting speed has been found which will cause the edge of the tool to be completely ruined at the end of the twenty minutes. This speed is then called the "standard speed." As an improvement on each of the previous methods of testing, the writer ventures to submit a new method, which he calls the "speed-increment test," and which he has found to give reliable results with a minimum expenditure of time and material. The method is as follows: A testing lathe sufficiently large for the purpose, and driven electrically, is so fitted as to be capable of a very fine adjustment of speed of rotation. The tool to be tested is started on a standard cut—say, ½ by 1/12—in the testing lathe at a surface speed of, say, 30 feet per minute, and the cutting is allowed to proceed under a gradually increasing rate of speed by equal increments of one foot per minute, each minute throughout the test, until the tool breaks down. That is to say, the speed increment is increased gradually and regularly, while the test is proceeding, in the same way as the load increment is increased in the tensile test of a steel bar in the testing-machine. Then, if the mean cutting speed in inches from start to finish of the trial be multiplied by the area of the cut, the result is equal to the number of cubic inches of material turned off by the tool during the test, and this is the measure adopted to represent the merit of the tool.

TESTS OF THE NEW HAVEN FREIGHT LOCOMOTIVES.

THE Electric Railway Journal describes some tests of the New York, New Haven and Hartford Railroad, which tests were completed on March 18th. The first series of trial runs in freight service was made with electric locomotive No. 071, a machine which is of the articulated truck type. In designing this locomotive the aim was to build a unit which could haul freight trains up to 1,600 tons weight at 35 miles per hour, and could also be used to haul heavy passenger trains of 800 tons at a speed of 45 miles per hour. For this reason it was equipped with alternating and direct-current collecting and control apparatus to enable it to run over the New York Central third-rail tracks into the Grand Central Station. On test for tractive effort on both alternating- and direct-current the locomotive developed a maximum tractive effort at the rail of 51,000 pounds and started and accelerated a train of coal cars weighing 2,100 tons on a 0.5 per cent grade. On February 12th the locomotive began a service test of 2,000 miles, hauling regular freight trains between Stamford and New Rochelle, 17 miles. The electric locomotive was coupled in front of the steam locomotives which were allowed to drift. Regular trips were made every day; the daily runs were between 100 and 120 miles with no road failures. At no time was the capacity of the motors fully taxed, and the speeds attained were limited only by the fears of the operating department. It is believed that the present running time of freight trains between Harlem River yards and Stamford can be reduced nearly 50 per cent when the Harlem River branch is electrified below New Rochelle. While rapid acceleration is not so important in freight service, the results attained with this locomotive are interesting as an index of its reserve power. With a trailing load of 1,600 tons the locomotive accelerates at the rate of 0.2 mile per hour per second, attaining a speed of 12 miles per hour at the end of 1 minute. With an 800-ton train, which is equivalent to 12 heavy passenger cars, the rate of acceleration is 0.45 mile per hour per second. A second experimental alternating-current freight locomotive of the side-rod type is nearing completion at the Westinghouse works for the New York, New Haven and Hartford Railroad. The locomotive consists of two separate units each complete in itself, but designed to be operated in pairs. Each unit comprises two pairs of driving wheels and a leading pony truck mounted in a forged frame of the locomotive type. An alternating- and direct-current motor of 750 horse-power is mounted on top of the frame with its center line 18 inches in the rear of the forward driving axle. Forward of the front driver is a jack shaft extending across between side frames and carrying on each end a crank-arm keyed to each end, and connecting rods on each side extend down through the cab floor to the jack shaft crank-arms. The two driving wheels on each side are coupled to the jack shaft crank-pin by locomotive rods of the ordinary type. The auxiliary apparatus on the locomotive is distributed between the two halves of the cab, but each unit is supplied with independent current-collecting devices for both alternating and direct current, ventilating blower, auto-transformer, unit switches, controller, and change-over panel. Either motor may be operated without the other.

To Cleanse Soiled Plaster Casts.—Prepare a thick starch paste by pouring starch, mixed in cold water, into boiling water and coat the object to be cleansed with the paste. After the paste is dry, it is readily detached from the plaster, bringing the dirt off with it.

THE SHEPHERDS OF PALESTINE.

BY HAROLD J. SHEPSTONE.

SHEPHERD AND SHEEP AMONG THE HILLS OF JUDEA.

FEW sights in the Holy Land stir the imagination more than the native shepherd and his flock of sheep. Whether you meet them on the hills or in the plains outside Jerusalem, or on the more fertile valleys around the Sea of Galilee, there is something about them that singles them out for special notice. They at once carry the mind back to Biblical days—both shepherds and sheep being repeatedly mentioned in the Scriptures.

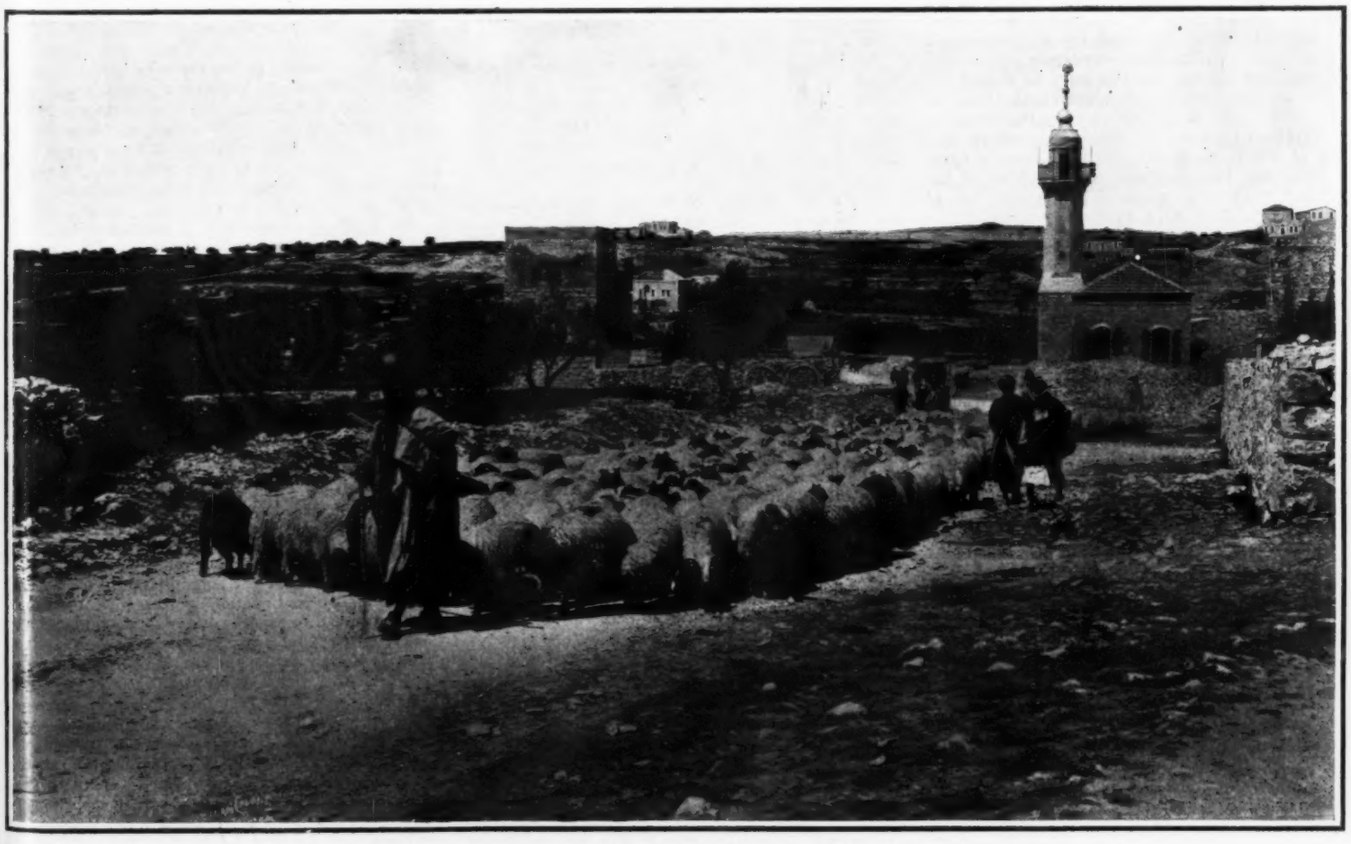
How many shepherds and sheep there are in Palestine to-day I would not like to say. Some few years ago the Turkish government returned the number of sheep in Palestine as over four million. The herds vary considerably in size, some numbering only a score or even less, while others run into several hundreds. Speaking generally, a shepherd will be found attending to the wants of about fifty or eighty sheep. These wild sons of the mountains belong, of course, to the native population, which may be divided into three groups—the townspeople, or Mellanijeh; the peasants or dwellers in villages, called fellaheen; and the Bedouins, those nomads who live in tents and spend their lives roaming. The shepherds, therefore, come under the head of peasants or fellaheen; but even among these they are virtually a race apart. They live entirely with their flocks; night and day their sheep and goats are their sole friends and companions. They tend them by day, and guard them by night.

There is one interesting fact about these men which has generally escaped notice, and it is this: The shepherds are undoubtedly the original dwellers of this historic country. They tended to the wants of their sheep and led them from pasture to pasture among the hills and valleys long before the coming of the Children of Israel. No less an authority than Col. Condor has styled them "Modern Canaanites," declaring that they are "the descendants of the Semitic race which the Egyptians found in Palestine before the time of the Hebrew conquest." Then pride, isolation, narrowness of mind, and close intermarriage have all tended to preserve their ancient character intact. Indeed, these stubborn men of the mountains have never been absorbed or expelled by any conquering people.

When I have gazed at these men in the streets of Jerusalem, ruddy of face, stalwart and dignified, they have always seemed out of place. The hillside is their home and temple. Their dress, demeanor, and bearing bespeak them as sons of the fields. Their shoes are of the roughest description, almost circular in appearance. They wear an outer garment of bright colors. It is woven from camel's hair, as was that of John the Baptist. It is without seam, square, and sleeveless, and hangs in picturesque folds from the shoulder. A kerchief for the head, tied in two black rings of rope and wool, completes the shepherd's outfit. In the winter, however, they take an undressed fleece, which they girdle about their loins, when they more than ever appear like members of their own flocks.

Then the shepherds of the Holy Land are men of some initiative and intelligence. Their business is at once an honorable one yet full of difficulty and danger. For this latter reason many of them carry fire-arms or other weapons in the shape of heavy wooden clubs and even slings. The guns are invariably old-fashioned flint-lock muskets or some other obsolete type of fire-arm. With these weapons the shepherd protects his flock from wild beasts—hyenas, leopards, panthers, and wolves. But his worst enemy is not the wild animals of the country, but the roving Bedouins, who are always making raids and carrying off the sheep, with the result that even to-day many a good shepherd is called upon to lay down his life for the sheep.

Much has been made of the fact that the shepherds of this sacred land lead their sheep. This custom has arisen through the absence of roads and the scanty nature of the pasturage found on the mountain sides.



ARMED SHEPHERD LEADING HIS FLOCKS INTO JERUSALEM

It would be impossible to drive the flocks from place to place unless dogs were employed, and there are no sheep dogs in eastern countries. Hence the shepherd goes on in front, the sheep following behind, the shepherd's boy, as a rule, bringing up the rear. Thus one of the shepherd's principal duties is to lead his sheep from pasture to pasture.

On the stony hillsides of Judea the finding of fresh pasturage is no easy task. Tufts of rough, stringy grass struggle through the poor limestone; but the fodder is scanty. In the Province of Galilee and around Tiberias, on the Sea of Galilee, however, pasturage is more abundant, and the shepherd's work is consequently lighter. Farther north again, in the Lebanons, there are very large flocks, grass being more plentiful here. But the shepherds of the Lebanons are ever in danger. Wild beasts abound, while they are also open to attack from the roving Bedouins. For this reason they carry fire-arms, and many a bloody tragedy is enacted in the plains here under the starlit skies between the ever-watchful shepherd and the Bedouin robber.

As to the sheep themselves, they are distinctly of the Syrian breed, and famed for their "fat tails." This is one of the peculiarities of the sheep of certain eastern countries. Herodotus was the first to call attention to the enormous tails of these eastern sheep. He gave them a length of "three cubits and more," and declared that the shepherds constructed little carriages to save them from dragging in the dust. No one has yet discovered these carriages. Perhaps his estimate of length should refer to the circumference of the rump—for such it is, rather than tail—of this breed of Syrian sheep. This rump grows to a huge size, and consists entirely of rich fat, which forms a kind of sweet butter, much appreciated by the natives.

To the traveler in the Holy Land the sheep are a perpetual joy, for they seem to carry a burden of sunshine in solution on their backs; they soften the hard lines in a landscape, and lend interest and romance to the most desolate hillside. They and their black brethren, the goats, are often united in one flock, and form a pleasing contrast. But when they are led from one pasture to another, the sheep are invariably on the right side and the goats on the left. Often, too, a shepherd will be encountered carrying a little lamb in his strong arms.

Perhaps I cannot do better than close this little sketch of the shepherd and his sheep by quoting the remarks which Dr. Adam Smith has made upon the subject. "I do not remember," he says, "ever to have seen in the East a flock of sheep without a shepherd. . . . . On some high moor, across which at night the hyenas howl, when you meet him, sleepless, far-sighted, weather-beaten, armed, leaning on his staff, and looking out over his scattered sheep, every one of them on his heart, you understand why the Shepherd of Judea sprang to the front in his people's history; why they gave his name to their king, why Christ took him as the type of self-sacrifice."

THE GOVERNMENT'S MONEY LAUNDRY.

HOW OLD PAPER NOTES ARE WASHED.

BY THOMAS D. GANNAWY.

VERY few people realize the vast amount of money that is spent by the government each year for the manufacture of our paper currency and the maintenance of its circulation. It actually costs "Uncle Sam" $13.50 per thousand notes (regardless of denominations) to manufacture and put them into circulation. This is equal to an annual interest of almost 1¼ per cent on the $1 notes, which have an average life of only fourteen months. The life of small notes is very much shorter than that of the larger denominations, because of the greater amount of handling which they receive, therefore, the greater part of the expense of our paper currency circulation is incurred with the smaller denominations. This is better understood when we learn that the $1, $2, and $5 notes—excluding national bank currency—compose about 43¾ per cent of the number of notes in circulation. The larger denominations are fit for circulation much longer after they are first issued than the smaller ones, hence do not have to be redeemed so soon thereafter.

A very large portion of the notes which come back to the Treasury Department for redemption are not worn out, but are merely soiled from rough usage.

As a result of the clamor for economy in public expenditures, and also for clean paper currency, the Director of the Bureau of Engraving and Printing, Mr. Joseph E. Ralph, conceived the idea of putting these soiled notes through a laundering process and then back into circulation. The more he studied the scheme the more feasible it appeared to him. He submitted his plan to the Secretary of the Treasury, and he (the Secretary) appointed a committee composed of Mr. C. S. Pearce of the Treasurer's office, chairman; Mr. Burgess Smith of the Bureau of Engraving and Printing, chemist; Mr. George Leet of the Secretary's office; Mr. C. C. Pusey, Assistant Treasurer at Baltimore, and Mr. L. R. Acton, a paper expert of Washington.

These men have been experimenting with the laundering process for about seven months, and, as a result of these experiments, have proved beyond a reasonable doubt the feasibility of the scheme.

The process of washing the money is very simple, being almost identical to that used by the steam laundries all over the country. The chairman of the committee says: "The scheme of laundering paper money is here to stay, but the exact method of washing it has not yet been decided upon." The committee are experimenting with two or three styles of tubs. One of the most feasible plans is to put the notes into a wire contrivance, which holds them in such manner as to prevent any friction whatever, and also prevents them from piling together. This contrivance consists of a number of wire trays with a single layer of notes in each, and then stacked together and placed inside of a cylindrical tub filled with suds made with a soap especially prepared for this work by Mr. Burgess Smith, chemist, who has charge of the practical part of it. The soap is composed principally of potash and some high grade oils. Mr. Smith is now trying to manufacture a soap which will cleanse the money and at the same time bleach it.

After the trays of money have been placed in the suds, which have been heated to a temperature of 130 deg. to 140 deg. F., the tub is closed and started to revolving. A greater temperature than 140 deg. F. has proved to be injurious to the money. This process is kept going for ten to fifteen minutes, during which time the dirt has been removed from the notes. They are then taken out and rinsed the same way in clear water for about five minutes to remove all the suds. Next it is put into a germicide bath of the nature of formaldehyde, thereby killing all germs which may be lurking around on it. It is taken from this and bleached and partially dried. The next step is to put it through the sizing tub, or vat as it may be called. This vat contains a 10 per cent solution of glue with a little alum in it. There are a number of small endless belts, which pass over rollers at the top of either end of the vat and under one in the solution. The money is fed in between these belts at one end of the vat, and they carry it down through the solution and drop it out at the other end. It is then taken to the ironing machine.

Here it is placed in stacks containing about forty notes each, with a piece of Fuller (or press) board separating the notes from each other. This Fuller board is a thin flexible substance, resembling a thin piece of sole leather. These stacks are taken one at a time and fed through between two heavy steel rollers, which are held together with a 30-ton pressure. Each stack of notes is put through two of these machines, which completes the ironing and gives them a glossy, new appearance.

The laundry is now washed and ironed, and the only thing left to be done is to place it in the drying room, for the purpose of getting rid of every particle of moisture that it may contain. It pays to launder money for the same reason that it pays to have your linen laundered instead of throwing it away and buying a new supply.

The yellow ink used on the gold certificates is of such a character that the potash dissolves it, and it is washed out, hence they cannot yet be laundered. So it is with the signatures of the bank officers on the national bank notes. The committee hope eventually to overcome this difficulty. As it is at present, they can only launder silver certificates and Treasury notes, but these compose a very large percentage of our paper money.

In my calculations I shall exclude national bank notes, as they are in a class of paper currency by themselves, and for the reason stated cannot yet be laundered. During the year 1909, there were 187,784,000 $1, $2, and $5 notes issued, and in the same period of time there were 177,412,809 notes of the same denominations destroyed. At the close of the year 1909 there were 222,365,692 notes of these three denominations still in circulation. The cost to the government for manufacturing and issuing these 187,784,000 notes was $2,535,084. The cost of destroying the 177,412,809 notes was $390,308.18, making a grand total of $2,925,392.18 for maintaining the circulation of notes of only three denominations for one year.

It is estimated that it will not cost more than one-tenth of one cent per note to launder them. It is claimed that laundering the notes will add at least eight months or 56 per cent to the life of them, thereby diminishing the annual redemptions by 56 per cent. The redeeming and issuing of the 177,412,809 notes in 1909 cost the government $2,787,155.23. With the new process 56 per cent of this, or $1,560,806.93 less $298,053.52, the cost of laundering and reissuing of the 56 per cent of the redemptions for 1909, would be saved. This would leave a net saving of $1,262,753.41 in one year on the circulation of $1, $2, and $5 notes only (national bank notes excluded).

SPINNING PAPER.

SOME years ago a Philadelphia carpet manufacturer said to the writer that in his line competition was so sharp, that his rivals could spin everything but sand. This was perhaps a trifle overdrawn; but as a matter of fact the spinning industry has progressed so far that fibers are now spun which formerly, by reason of their extreme tenderness or shortness, could not be used in textile work.

That such progress has been made is advantageous in a large number of lines, especially as many kinds of raw material are getting scarce or dear, or both; further, as there are many products now wasted, which it is advantageous to use. Wool and silk, linen, hemp, cotton—these are the principal fibers which are spun, and in many lines they hold their own; but there are some branches in which they are being supplanted by artificial materials, or by others which are "ennobled," as the Germans say, by being made to look like their betters. A case in point is artificial silk, made from cellulose, which latter really has no fiber; and if this can be spun, why not paper, which really has some fiber, short though it may be?

The first inventor of paper yarn and fabrics was naturally a German, as the Germans pay more attention to imitations and substitutes than any other people. As far back as 1887 there was a patent in that great center of the textile industry, Chemnitz, for spinning paper. This was followed by others in 1891, 1897 to 1901; and the products appear on the market under various names, as for instance "Licella," "Silvalin" (sic.) "Xylolia," etc.

One of the principal places of manufacture is Waldhof near Mannheim; another, Adorf. The raw material is given, by means of chemical treatment, a strength and elasticity which it otherwise lacks; and can be dyed or bleached if desired. It is made into carpets, bags, tents, hats, etc. The material has no smell, even when wet; so that materials may be kept in sacks thereof, which in jute bags would acquire a disagreeable smell. A German trade paper states that the material costs only one-third as much as cotton, and only one-tenth as much as flax.

Shoes and slippers are made from the material, and the latter sold at wholesale for 25 cents per dozen pairs! The cost of the material for a suit of clothes is said to be only $1. It is stated that by treatment with gelatine the material is made not only damp-proof and water-proof, but also washable.

In accordance with the appropriation made by Congress for the continuation of the investigation of Alaskan mineral resources by the United States Geological Survey twelve parties have been organized for work in Alaska during the season of 1910. Three of these parties are now at work and most of the others are on the way to the field. As in previous years, the work will consist of explorations, reconnoissances and detailed surveys, study of the geology and mineral resources, and, in the placer districts, stream gaging. The parties were organized and started for the field at the earliest date possible so that they may be able to utilize fully the brief period in which surveys can be made.

MODERN MATHEMATICAL METHODS.*

PRINCIPLES AS DISTINGUISHED FROM PROCESSES.

BY PROF. E. W. HOBSON, SC.D., F.R.S.

THE belief is very general among instructed persons that the truths of mathematics have absolute certainty, or at least that there appertains to them the highest degree of certainty of which the human mind is capable. It is thought that a valid mathematical theorem is necessarily of such a character as to compel belief in any mind capable of following the steps of the demonstration. Any considerations tending to weaken this belief would be disconcerting, and would cause some degree of astonishment. At the risk of this, I must here mention two facts which are of considerable importance as regards an estimation of the precise character of mathematical knowledge. In the first place, it is a fact that frequently, and at various times, differences of opinion have existed among mathematicians, giving rise to controversies as to the validity of whole lines of reasoning, and affecting the results of such reasoning; a considerable amount of difference of opinion of this character exists among mathematicians at the present time. In the second place, the accepted standard of rigor—that is, the standard of what is deemed necessary to constitute a valid demonstration, has undergone change in the course of time. Much of the reasoning which was formerly regarded as satisfactory and irrefutable is now regarded as insufficient to establish the results which it was employed to demonstrate. It has even been shown that results which were once supposed to have been fully established by demonstrations are, in point of fact, affected with error. I propose here to explain in general terms how these phenomena are possible. In every subject of study, if one probes deep enough, there are found to be points in which that subject comes in contact with general philosophy, and where differences of philosophical view will have a greater or less influence on the attitude of the mind toward the principles of the particular subject. This is not surprising when we reflect that there is but one universe of thought, that no department of knowledge can be absolutely isolated, and that metaphysical and psychological implications are a necessary element in all the activities of the mind. A particular department, such as mathematics, is compelled to set up a more or less artificial frontier, which marks it off from general philosophy. This frontier consists of a set of regulative ideas in the form of indefinables and axioms, partly ontological assumptions, and partly postulations of a logical character. To go behind these, to attempt to analyze their nature and origin, and to justify their validity, is to go outside the special department and to touch on the domains of the metaphysician and the psychologist. Whether they are regarded as possessing apodeictic certainty or as purely hypothetical in character, these ideas represent the data or premises of the science, and the whole of its edifice is dependent upon them. They serve as the foundation on which all is built, as well as the frontier on the side of philosophy and psychology. A set of data ideally perfect in respect of precision and permanence is unattainable—or at least has not yet been attained; and the adjustment of frontiers is one of the most frequent causes of strife. As a matter of fact, variations of opinion have at various times arisen within the ranks of the mathematicians as to the nature, scope, and proper formulation of the principles which form the foundations of the science, and the views of mathematicians in this regard have always necessarily been largely affected by the conscious or unconscious attitude of particular minds toward questions of general philosophy. It is in this region, I think, that the source is to be found of those remarkable differences of opinion among mathematicians which have come into prominence at various times, and have given rise to much controversy as to fundamentals. The proposition $7 + 5 = 12$, taken as typical of the propositions expressing the results of the elementary operations of arithmetic, has since the time of Kant given rise to very voluminous discussion among philosophers, in relation to the precise meaning and implication of the operation and the terms. It will, however, be maintained, probably by the majority of mankind, that the theorem retains its validity as stating a practically certain and useful fact, whatever view philosophers may choose to take of its precise nature—as, for example, whether it represents, in the language of Kant, a synthetic or an analytic judgment. It may, I think, be admitted that there is much cogency in this view; and, were mathematics concerned with the elementary operations of arithmetic alone, it could fairly be held that the mathematician, like the practical man of the world, might, without much risk, shut his eyes and ears to the discussions of the philosophers on such points. The exactitude of such a proposition, in a sufficiently definite sense for practical purposes, is empirically verifiable by sensuous intuition, whatever meaning the metaphysician may attach to it. But mathematics cannot be built up from the operations of elementary arithmetic without the introduction of further conceptional elements. Both in geometry and in analysis our standard of what constitutes a rigorous demonstration has in the course of the nineteenth century undergone an almost revolutionary change. That oldest textbook of science in the world, "Euclids' Elements of Geometry," has been popularly held for centuries to be the very model of deductive logical demonstration. Criticism has, however, largely invalidated this view. It appears that, at a large number of points, assumptions not included in the preliminary axioms and postulates are made use of. The fact that these assumptions usually escape notice is due to their nature and origin. Derived as they are from our spatial intuition, their very self-evidence has allowed them to be ignored, although their truth is not more obvious empirically than that of other assumptions derived from the same source which are included in the axioms and postulates explicitly stated as part of the foundation of Euclid's treatment of the subject. The method of superimposition, employed by Euclid with obvious reluctance, but forming an essential part of his treatment of geometry, is, when regarded from his point of view, open to most serious objections as regards its logical coherence. In analysis, as in geometry, the older methods of treatment consisted of processes of deduction eked out by the more or less surreptitious introduction, at numerous points in the subject, of assumptions only justifiable by spatial intuition. The result of this deviation from the purely deductive method was more disastrous in the case of analysis than in geometry, because it led to much actual error in the theory. For example, it was held until comparatively recently that a continuous function necessarily possesses a differential coefficient, on the ground that a curve always has a tangent. This we now know to be quite erroneous, when any reasonable definition of continuity is employed. The first step in the discovery of this error was made when it occurred to Ampere that the existence of the differential coefficient could only be asserted as a theorem requiring proof; and he himself published an attempt at such proof. The erroneous character of the former belief on this matter was most strikingly exhibited when Weierstrass produced a function which is everywhere continuous, but which nowhere possesses a differential coefficient; such functions can now be constructed *ad libitum*. It is not too much to say that no one of the general theorems of analysis is true without the introduction of limitations and conditions which were entirely unknown to the discoverers of those theorems. The difference between a mathematical theory in the making and as a finished product is, perhaps, most strikingly illustrated by the case of geometry, as presented in its most approved modern shape. It is not too much to say that geometry, reduced to a purely deductive form—as presented, for example, by Hilbert, or by some of the modern Italian school—has no necessary connection with space. The words "point," "line," "plane" are employed to denote any entities whatever which satisfy certain prescribed conditions of relationship. Various premises are postulated that would appear to be of a perfectly arbitrary nature, if we did not know how they had been suggested. In that division of the subject known as metric geometry, for example, axioms of congruency are assumed which, by their purely abstract character, avoid the very real difficulties that arise in this regard in reducing perceptual space-relations of measurements to a purely conceptual form. Such schemes, triumphs of constructive thought at its highest and most abstract level as they are, could never have been constructed apart from the space-perceptions that suggested them, although the concepts of spatial origin are transformed almost out of recognition. But what I want to call attention to here is that, apart from the basis of his geometry, mathematicians would never have been able to find their way through the details of the deductions without having continual recourse to the guidance given them by spatial intuition. If one attempts to follow one of the demonstrations of a particular theorem in the work of writers of this school, one would find it quite impossible to retain the steps of the process long enough to master the whole, without the aid of the very spatial suggestions which have been abstracted. This is perhaps sufficiently warranted by the fact that writers of this school find it necessary to provide their readers with figures, in order to avoid complete bewilderment in following the demonstrations, although the processes, being purely logical deductions from premises of the nature I have described, deal only with entities which have no necessary similarity to anything indicated by the figures. There are at the present time some signs of reaction against the recent movement of reform in the teaching of geometry. It is found that the lack of a regular order in the sequence of propositions increases the difficulty of the examiner in appraising the performance of the candidates, and in standardizing the results of examinations. That this is true may well be believed, and it was indeed foreseen by many of those who took part in bringing about the dethronement of Euclid as a textbook. From the point of view of the examiner it is without doubt an enormous simplification if all the students have learned the subject in the same order, and have studied the same textbook. But, admitting this fact, ought decisive weight to be allowed to it? I am decidedly of opinion that it ought not. An objection of a different character to the newer modes of teaching geometry has been frequently made of late. It is said that the students are induced to accept and reproduce, as proofs of theorems, arguments which are not really proofs, and thus that the logical training which should be imparted by a study of geometry is vitiated. If this objection really implies a demand for a purely deductive treatment of the subject, I think some of those who raise it hardly realize all that would be involved in the complete satisfaction of their requirement. The great and increasing importance of a knowledge of the differential and integral calculus for students of engineering and other branches of physical science has led to the publication during the last few years of a considerable number of textbooks on this subject intended for the use of such students. Some of these textbooks are excellent, and their authors, by a skilful insistence on the principles of the subject, have done their utmost to guard against the very real dangers which attend attempts to adapt such a subject to the practical needs of engineers and others. It is quite true that a great mass of detail which has gradually come to form part—often too large a part—of the material of the student of mathematics, may with great advantage be ignored by those whose main study is to be engineering science or physics. Yet it cannot be too strongly insisted on that a firm grasp of the principles, as distinct from the mere processes of calculation, is essential if mathematics is to be a tool really useful to the engineer and the physicist. There is a danger, which experience has shown to be only too real, that such students may learn to regard mathematics as consisting merely of formulæ and of rules which provide the means of performing the numerical computations necessary for solving certain categories of problems which occur in the practical sciences. Apart from the deplorable effect, on the educational side, of degrading mathematics to this level, the practical effect of reducing it to a number of rule-of-thumb processes can only be to make those who learn it in so unintelligent a manner incapable of applying mathematical methods to any practical problem in which the data differ even slightly from those in the model problems which they have studied. Only a firm grasp of the principles will give the necessary freedom in handling the methods of mathematics required for the various practical problems in the solution of which they are essential.

* Abstract of a paper read before the British Association for the Advancement of Science, at Sheffield.

A case for the protection of jewels, bank notes, deeds, etc., from injury by fire must be made of incombustible material and so constructed as to prevent the access of corrosive gases, as well as of excessive heat, to the interior. A new French device for this purpose, called the Securitas case, consists of two boxes made of asbestos, one of which is much smaller than the other and is placed inside it, being prevented from touching the bottom, sides or top of the outer box by a number of blocks of asbestos. The wide air space thus left forms an excellent thermal insulator and the asbestos is a very poor conductor of heat. Hence the temperature inside the inner box remains comparatively low even when the outer box is strongly heated.—La Nature.

PRACTICE AND THEORY OF AVIATION.—III.*

THE LEADING AEROPLANES.

BY GROVER CLEVELAND LOENING, A.M.

Continued from Supplement No. 1817, Page 277.

7. THE SOMMER BIPLANE.

IN June, 1909, Roger Sommer purchased a biplane constructed by Henri Farman, and on July 3rd he made his first flight. Scarcely a month later he held the world's record for duration of flight, having flown continuously for two and a half hours. His sudden jump into the ranks of the great aviators was remarkable and showed that, after all, it was not so hard to learn to fly well. At Rheims and at Doncaster, during the fall of 1909, he won many prizes, but shortly after this gave up flying on the Farman aeroplane and proceeded to design and construct his own. On January 6th, 1910, this biplane was completed and tried out for the first time. M. Sommer at once succeeded in making three perfect flights of several kilometers each, and after three days of experimenting, a long cross-country flight was made. This aeroplane is also operated by Lindpainter and Legagneux.

The Frame.—The materials of construction of the frame are chiefly hickory and ash, steel joints and steel tubing. The general character and appearance of the frame is somewhat similar to that on the Farman machine.

The Supporting Plane.—Two identical and directly superposed rigid planes carry the machine. The surfaces are made of rubber cloth covering wooden ribs. The sectional curvature of the surfaces is not as highly arched as on most other types, but is more nearly as in the Wright machine, a very even and gently sloping curve. The spread of the planes is 33 feet, the depth 5.2 feet, and the surface area 326 square feet.

The Direction Rudder.—The direction rudder consists of a single surface at the rear of 10 square feet area. It is operated by a foot lever, governed by the aviator. To turn to the right this lever is turned to the right, etc.

The Elevation Rudder.—At a distance of 8.25 feet in front of the main cell, and supported on framing carried down to the skids, is situated the single surface elevation rudder. This is governed by a large lever in the aviator's left hand, which when pushed out turns down the rudder, and when pulled in turns up the rudder, thus respectively lowering and raising the aeroplane.

Transverse Control.—The lateral equilibrium is secured by means of two wing tips, one placed on either end, at the rear of the upper main plane. In distinction to the Farman there are no wing tips on the lower plane. These wing tips are governed by cables leading to a brace attached to the aviator's body. The aviator by swaying to the right, for example, pulls down the wing tip on the left side and pulls up the wing tip on the right side. This causes the left end to rise and the right end to descend.

When turning to the left, for example, at the same time as the foot lever is turned, the aviator leans to the left, and by thus causing the right end to rise, increases the exactness of the turn.

Keels.—A single horizontal plane of 55 square feet area and of very light construction is placed at the rear and steadies the machine longitudinally. This plane is movable, although it does not act as a rudder. A lever at the right hand of the aviator, which automatically "locks," enables the angle of incidence of this surface to be varied at will, thus increasing the attainable stability.

Propulsion.—A 50 horse-power Gnome rotary air-cooled 7-cylinder motor, placed at the rear of the main cell, drives direct a Chauviere wooden propeller of 7 feet diameter and 5.2 feet pitch at 1,200 r.p.m.

The Seat for the aviator is fitted more comfortably than in other aeroplanes, and is placed on the front of the lower plane at the center.

The Mounting consists of a combination of two large wheels at the front and two smaller ones at the rear. The front wheels are attached by rubber springs to two skids, built under the frame. The skids themselves are attached to the main cell by uprights, the joints being made of a springy sheet of metal bolted to the framing. This adds still further to the extremely springy character of the mounting.

The total weight varies from 800 to 900 pounds; the speed is 46 miles per hour; 16 pounds are lifted per horse-power, and 2.76 pounds carried per square foot of surface. The aspect ratio is 6.35 to 1.

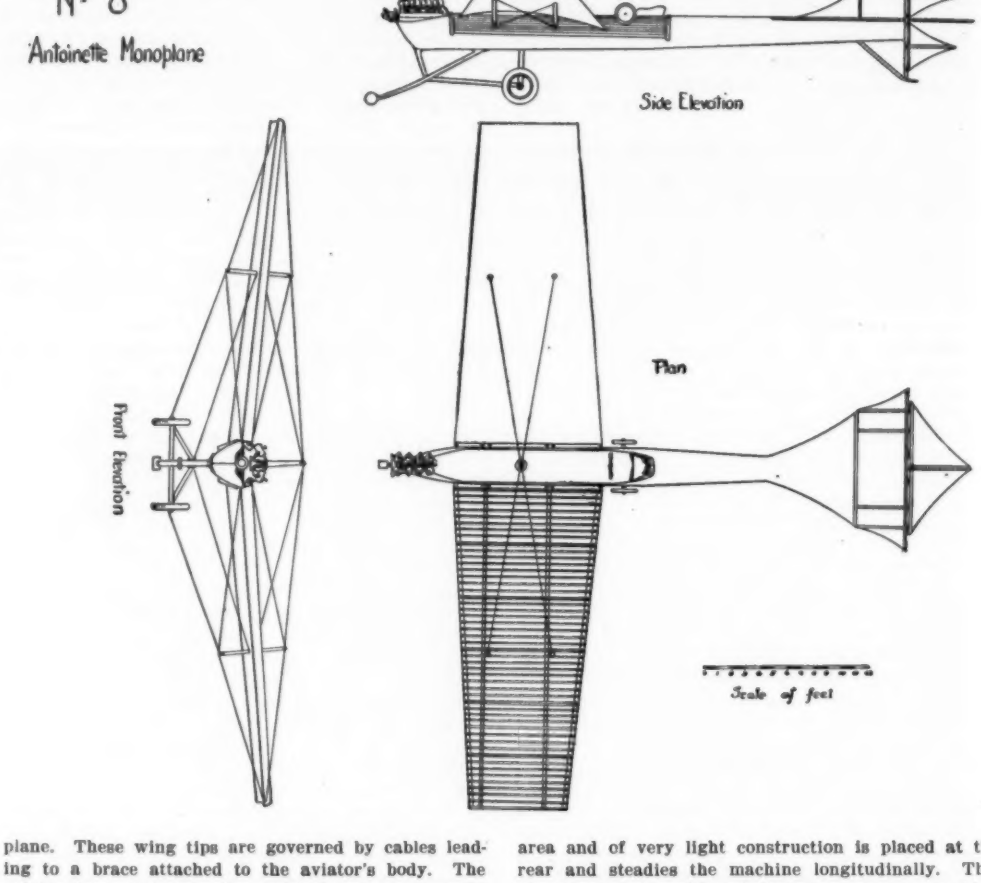
Recent Alterations.—For racing purposes the Sommer has recently been altered. The two end panels of the lower surface have been eliminated, very much as on some of the Farman machines. This reduces the area of surface to 256 square feet, and makes the loading 3.25 pounds per square foot.

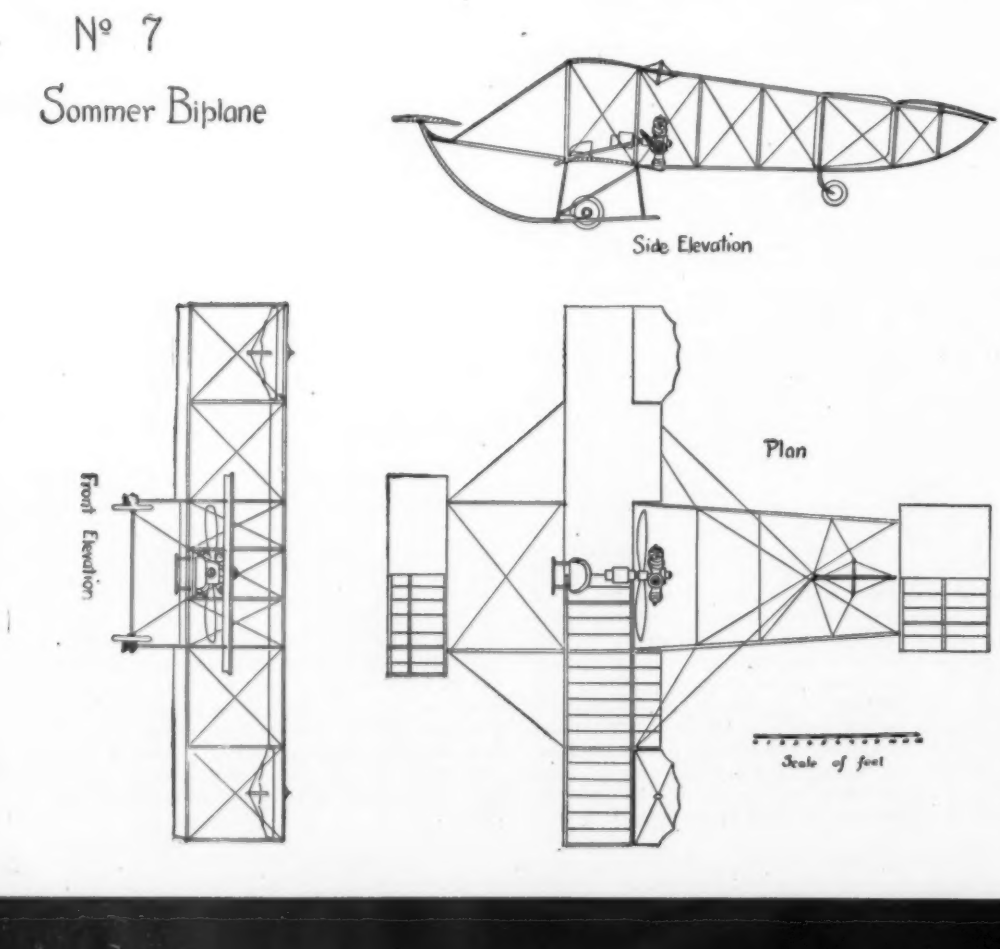
References.—Aerophile, v. 18, p. 61, February 1st, 1910.

8. THE ANTOINETTE MONOPLANE.

M. Levavasseur, designer of the Antoinette motor boats, is credited with the design of this type. After building some experimental machines, notably the Gastambide-Mengin monoplane, the "Antoinette IV." was built for M. Latham. This machine was controlled transversely by means of wing tips, while at present the warpable surface control is used. The Antoinette is remarkably well built from an engineering standpoint, and has been very successfully operated by M. Latham in exceptionally high winds. Messrs. Kuller, de Mumm, and Labouchère, are also flying monoplanes of this type, and several have been purchased by the French army.

The Frame.—A long narrow girder-like frame of cedar, aluminium and ash carries at its front portion

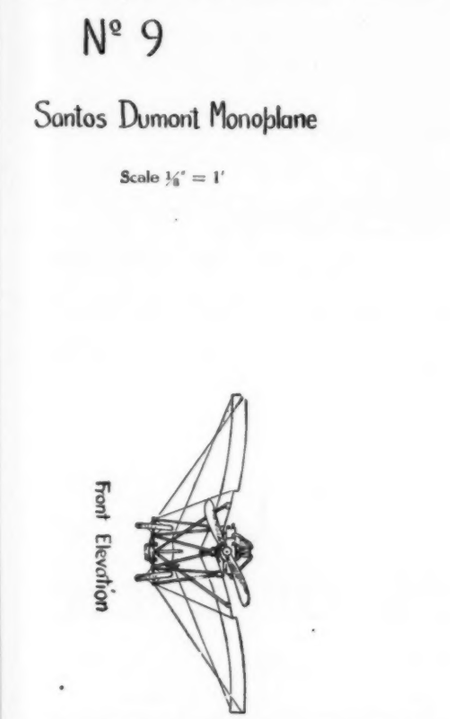




* Accepted as thesis for the degree of A.M., Columbia University, June, 1910.

the main plane, at the extreme front end the propeller, and at the rear the rudders This disposition is similar to that in all the monoplanes considered here, except the Pfitzner.

The Supporting Plane.—The carrying plane consists of a single surface divided into two halves of trapezoidal shape, at a slight dihedral angle and constructed of rigid trussing, nearly 1 foot thick at the center,



covered over and under with a smooth, finely pumiced silk. The plane is braced also from a central mast.

The spread is 46 feet, the average depth 8.2 feet, and the surface area 370 square feet.

The Direction Rudder.—The direction rudder consists of two vertical triangular surfaces at the rear, of 10 square feet area. They are moved jointly by means of wire cables running from a lever worked by the aviator's feet. When this pedal, which moves in a horizontal plane, is turned to the left the aeroplane will turn to the left.

The Elevation Rudder.—The elevation rudder consists of a single triangular horizontal surface placed at the extreme rear, and 20 square feet in area. It is governed by cables leading from a wheel placed at the aviator's right hand. To ascend, the wheel is turned up. This causes the inclination of the elevation rudder with regard to the line of flight, to be decreased, and the machine, therefore, rises.

Transverse Control.—The transverse equilibrium is corrected by warping of the outer ends of the main plane very much as in the Wright machine. But the front ends are movable and the rear ends rigid throughout in the Antoinette, while the opposite is the case in the Wright biplane.

The wheel at the aviator's left hand, through cables and a sprocket gear, placed at the lower end of the central mast, controls the warping. For correcting a dip downward on the right the right end of the wing is turned up, and at the same time the left end is turned down, thus restoring balance.

Keels.—At the rear, leading up to the rudders, are tapered keels, both horizontal and vertical, that add greatly to the bird-like appearance of the aeroplane.

Propulsion.—A 50 horse-power, 8-cylinder Antoinette motor, placed at the bow, drives direct a two-bladed metal propeller of 7.25 feet diameter and 4.3 feet pitch at 1,100 revolutions per minute.

The Seat for the aviator is placed in the frame back of the main plane. A seat for a passenger is provided in front of and a little below the aviator's seat.

The Mounting is essentially on a large pair of wheels fitted to a pneumatic spring, and placed at the central mast. In addition a single skid to protect the propeller when landing is placed in front, and another is attached in the rear.

The total weight is from 1,040 to 1,120 pounds; the speed is 43 miles per hour; 30 pounds are lifted per horse-power, and 3.96 pounds per square foot of supporting surface. The aspect ratio is 5.6 to 1.

Recent Alterations.—The Antoinette has been slightly altered. The spread is now 49.3 feet, the area 405 square feet, and the total weight from 1,200 to 1,350 pounds. 27 pounds are lifted per horse-power and 3.33 pounds per square foot of surface. The aspect ratio is 6 to 1. A new 100-horse-power type is also being used for racing.

References.—Aerophile, v. 17, pp. 7, 488; Flight, v. 1, pp. 662, 681; Aeronautics, v. 4, p. 63; SCI. AMERICAN, v. 100, p. 352; Rev. de l'Av., v. 4, p. 27; La Nature, v. 37, pp. 49, 329; Zeit. für Luftschiff, v. 13, p. 890; Encyl. d'Av., v. 1, p. 1; La Vie Auto., v. 9, p. 729; Flug Motor Tech., No. 22, p. 10; Boll. Soc. Aer. Ital., v. 6, p. 288; Zeit. Ver. Deut. Ing., v. 58, p. 1759; Genie Civil, v. 55, p. 340.

9. THE SANTOS-DUMONT MONOPLANE.

The first sustained flight of a motor aeroplane in Europe was made by M. Santos-Dumont on November 12th, 1906, in a biplane of his design. In 1907 he began work on a monoplane, and after much alteration, has finally evolved the highly successful and interesting little monoplane, the "Demoiselle." This is the smallest aeroplane in use to-day. Many machines of this type are being flown abroad, and their simplicity renders them quite popular.

The Frame.—The frame, which narrows toward the rear, is made of bamboo and steel joints, with several members of metal tubing.

The Supporting Plane.—The supporting plane has both sides slightly turned up from the center, and consists of a double layer of silk stretched very tightly over bamboo ribs. The plane is braced by wires to the central frame. The curvature is approximately the arc of a circle. The spread is 18 feet, the depth 6.56 feet and the area 113 square feet.

The Direction Rudder and the Elevation Rudder.—The two rudders are combined at the rear into two fan-shaped surfaces, one vertical and the other horizontal. They are pivoted on a single universal joint. The elevation rudder is 21 square feet in area, while the direction rudder is somewhat less. A lever at the aviator's right hand controls the movement of the elevation rudder, while a small steering wheel at the aviator's left hand controls the direction rudder. To rise the tail is moved up, while to turn to the right it is moved to the right.

Transverse Control.—Transverse control is effected in the Santos-Dumont by the warping of the main planes. This action is governed by a lever at the back of the aviator, and which fits into a socket sewed on his coat. If the aeroplane should suddenly tip up on the left, then the aviator, by moving quickly to the left, pulls down and increases the angle of incidence of the right side of the plane. The ribs of the plane are flexible in this machine.

Keels.—There are no keels in the Santos-Dumont monoplane.

Propulsion.—A 30 horse-power water-cooled Darracq 2-cylinder motor placed on the top of the plane at the front drives direct a 2-bladed Chauviere-wooden propeller 6.9 feet diameter and 6 feet pitch at 1,400 revolutions per minute. Clement-Bayard and Panhard motors are also used on this type of monoplane.

The Seat is a strip of canvas placed across the frame below the main plane.

The Mounting consists of two wheels at the front and a skid at the rear. No springs are provided on the wheels.

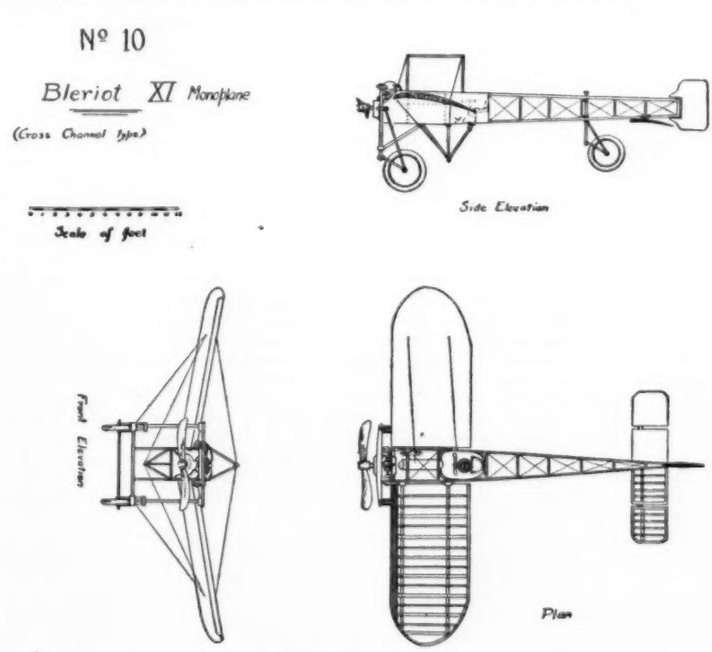
The total weight is from 330 to 370 pounds; the speed is 52 miles per hour; 12 pounds are lifted per horse-power and 3.1 pounds per square foot of surface. The aspect ratio is 2.7 to 1.

References.—Flight, v. 1, p. 603; SCI. AMERICAN SUP., v. 68, p. 317; SCI. AMERICAN, v. 97, p. 445; v. 99, p. 433; Aerophile, v. 15, p. 313; v. 16, p. 468; v. 17, pp. 435, 488; L'Aviation Ill., No. 34, p. 3; La France Aerienne, v. 14, p. 608; Omnia, No. 200, p. 281; Encyl. d'Av., v. 1, p. 126; Vorreiter, A., "Motor Flugapparate"; Zeit. Ver. Deut. Ing., v. 53, p. 1762; Genie Civil, v. 55, p. 466.

10. THE BLÉRIOT XI. MONOPLANE.

In 1906 M. Louis Blériot constructed and operated the first successful monoplane in the world. He subsequently built type after type, and finally in 1908 succeeded in making several brilliant and extended flights in his large monoplane "No. 8 Bis." Since then he has become world-famous by his flight of July 25th, when he crossed the English Channel, starting from Calais, and landing near Dover. This flight was accomplished in the No. XI. type monoplane, a small one-passenger machine, which is very simple, and has become extremely popular. Among the noted aviators who have flown this aeroplane type are also Delagrange, Le Blon, Leblanc, de Lesseps, Balsan, and Guyot. Over 140 of these machines have been manufactured and sold by M. Blériot since September, 1909.

The Frame.—The frame consists essentially of a long central body upon which the planes and rudders are attached. This central framework is very lightly but very strongly built of wood, and is cross-braced with wires throughout.



The Supporting Plane.—The main plane is situated near the front, and divided into two halves, each mounted on either side of the central frame by socket joints. The halves of the plane are easily detachable here, and when not in use are dismounted and placed in a vertical position along the frame, thus occupying little room.

The surfaces consist of ribs covered both above and below by Continental rubber fabric. Their curvature

is more pronounced than in most other types, and a sharp front edge is obtained by the use of aluminium sheeting. The two halves are at a slight dihedral angle.

The dimensions of the plane are spread 28.2 feet, depth 6.5 feet, and surface area 151 square feet.

The plane is braced above and below by wires from the central frame.

Direction Rudder.—The direction rudder consists of a small surface 4.5 feet in area placed at the extreme rear. Wire cables leading to a foot lever controlled by the aviator govern the movement of this rudder. For turning to the right, for example, the aviator turns this lever by his feet to the right.

Elevation Rudder.—The elevation rudder is divided into two halves, one mounted at each extremity of a fixed horizontal keel. The rudder is 16 square feet in area. It is operated by the front and back motion of a "bell crank" as it is called. This latter device is a universally pivoted lever, in front of the aviator, and in a normal position is vertical. At the lower extremity is attached a bell-shaped piece of metal, affording a means of attachment for the wires, and at the same time covering them to avoid their entanglement in the aviator's feet, etc. To ascend the aviator pulls this lever toward him, and to descend he pushes it away.

Transverse Control.—The lateral equilibrium is controlled by means of the warping of the main plane. The structure of this plane enables it to be warped, as in the Wright machine, but in this case about the base of each half, which is rigidly attached to the frame by the socket joints. The two halves are warped inversely by the side to side motion of the bell-crank. If the machine should tip up on the right, then the bell-crank is moved to the right. This increases the incidence of the lowered side and at the same time decreases that on the raised side, thus righting the machine. The combination of this side to side motion of the bell-crank, with the movement of the foot lever controlling the direction rudder, is used in turning.

Keels.—To preserve the longitudinal stability, a single fixed horizontal keel is placed at the rear. Its area is 17 square feet

Propulsion.—At the front of the central frame is placed the motor, a 3-cylinder Anzani, developing 23 horse-power. This motor drives direct at 1,350 r.p.m. a Chauviere wooden propeller, two-bladed, 6.87 feet in diameter and 2.7 feet pitch. Several of the more recent aeroplanes of this type have been fitted with Gnome 50 horse-power rotary engines, similarly placed.

The Seat is in the frame back of the main plane.

The Mounting consists of two large rubber-tired wheels at the front, mounted on an elastic chassis. The springs are made of thick rubber rope, and afford great elasticity and strength with small weight. There is also a small wheel at the rear.

The total weight is from 650 to 720 pounds and the speed is 36 miles per hour, although when a Gnome motor is used a speed of 48 miles per hour is attained; 29 pounds are lifted per horse-power and 4.5 pounds carried per square foot of surface. The aspect ratio is 4.35 to 1.

Alterations.—Very recently on this type the elevation rudder has been changed in form. It is now attached at the rear edge of a tapered keel much larger than the former one. The small wheel at the rear has been replaced by a skid, and the entire length of the central frame has been shortened considerably.

The regular one-passenger type of this monoplane has further been altered to the new No. XI. *bis*, in which the sectional curvature of the planes is made very nearly flat on the underside. This change has been found to greatly decrease the dynamic resistance of the machine without seriously decreasing the lift.

There are two new models of this machine which have been very successful. They are the No. XI. 2 *bis*, a two or three-passenger machine, and the No. XI. racing model.

The XI. 2 *bis* has a surface of 270 square feet, a spread of 36 feet, a depth of 7.6 feet, and a weight in flight of about 990 pounds. In other respects, it resembles the No. XI. *bis*. 19.8 pounds are carried per horse-power and 3.68 pounds per square foot of surface. The aspect ratio is 4.75 to 1.

The No. XI. racing model (*type de course*) is the machine upon which Morane recently established the speed record of the world by flying at almost 69 miles an hour.

This machine has a very short body, flat planes, and a reinforced frame. The surface has been reduced to 129 square feet, and the machine is equipped with one of the new 14-cylinder 100 horse-power Gnome motors. The total weight is about 750 pounds. Only 7.5 pounds are carried per horse-power, and as much as 5.76 pounds are lifted per square foot of surface.

References.—Zeit. Ver. Deut. Ing., v. 53, p. 1574; Aeronautics, v. 5, p. 118; Aerophile, v. 17, pp. 102, 106, 129, 318, 488; Encycl. d'Av., v. 1, pp. 3, 72, 92; Flug. Motor Tech., N. 22, p. 10; No. 23, p. 7; No. 25, p. 14; Flight, v. 1, p. 452; Boll. Soc. Aer. Ital., v. 6, p. 288; Locomocion Aerea, v. 1, p. 78; La Vie Auto, v. 9, p. 729; La Nature, v. 37, p. 32*b*; Sci. American Sup., v. 68, p. 136; Bracke, A., "Les Monoplans Blériot"; Glugsport, No. 24, p. 685; Genie Civil, v. 55, pp. 260, 344.

(To be continued.)

SHIP CRANES, COUNTERWEIGHTS, OR LOCKS.

SOME CANAL PROBLEMS.

In recent years there has been a lively discussion as to the best way to arrange for canal boats and large vessels to surmount differences in level of the water courses. The methods in vogue, including some which are not yet widely introduced, are divisible into three classes: (1) Locks, where there are practically no mechanical appliances for directly raising the vessel; (2) counterweights or floats; and (3) mechanico-hydraulic devices which may be said to correspond to the ordinary electric elevator. This subject is handled *in extenso* in a recent issue of Die Bauwelt. The hydraulicians of the old school held rather tenaciously to the slow-working and water-wasting system of locks, with their unavoidable heavy masonry construction and consumption of room. But more modern engineers regard this type as utterly unsuitable to great differences in level, especially where the available room is limited. Naturally, the electricians and the hydraulicians have been able to combine forces and effect the rapid and effective opening and closing of the lock gates, and in various ways to adapt the old system better to great differences of level than was formerly possible; also by means of reservoirs to effect a great saving in the water consumption—no small matter where the flow is slight.

Of the first mentioned of the two other systems, good examples may be seen on the Dortmund-Ens canal in Germany and at Les Fontinettes in France. Less important constructions of the same type are in Elbing, East Prussia, on the Oberländischer canal, where the vessels are raised and lowered "dry;" but these are calculated only for comparatively small vessels. The principle of construction consists in the use of an iron water tank, larger than the vessel to be raised, and which can receive and float this latter; it is guided vertically by suitable framework. This tank or trough has vertically closing gates which can shut it off from the water in the upper and the lower levels, and really forms a part of the canal itself, with the difference that it is movable so as to form a continuation of either the upper or the lower canal section. When this tank lies at the lower level, the water level therein is the same as that in the lower section; when it is raised, it corresponds to that of the upper canal section. This trough and its contents of water are counter-balanced by a number of floats like diving bells, arranged below it, and rising and falling therewith in wells filled with water.

This system has shown very good results in practice. Unfortunately, it is not suitable for great differences in level, because the shafts for the floats would have to be run down deeper than the rise and fall of the tank. For a level difference of 120 feet they would have to be about 160 feet deep. This fact prevents, at least for the present, the adoption of the system for great differences of level.

The third mentioned system is about the same as the second, with the exception that instead of floats to balance the weight of the tank when filled with water, this is raised by hydraulic cylinders.

In recent years bridge builders and machine constructors have invaded the sacred province of the hydraulicians, and made new projects for overcoming great differences in level by purely mechanical means, and brought them to the attention of parties interested in such problems. Also these plans have been worked out at a great expenditure of time and money even to the finest details; and although there seemed to be no human probability of their failing, they have been denied the possibility of actual construction.

One of the most important of systems is the "big drum" of the Nürnberger-Augsburger Maschinen Fabrik, which received the second prize at the international competition in Vienna in 1904. Although this project was so interesting in many particulars, it had little chance of being carried out constructively, because, leaving out of consideration several faults which characterized it, the cost of construction would have been too great.

Another place in which a mechanical system for ship raising would be suitable is the drop at the river Oder, near Leipe, on the Berlin-Stettin ship canal. Here the stepdown (or up) is 118 feet. Although the authorities have for years planned using a mechanical system of overcoming the level difference, they have decided at last on four locks each with 29.5 feet drop and about 840 feet apart. They are naturally fitted with all the most improved and tested modern appliances for saving water and hastening the operation of level changing. Alongside this system it is intended to build a larger, and it is to be hoped a more efficient, one to accommodate the greatly increasing traffic.

The capacity of the present system, when we consider the immense traffic already existing, is surprising; and it can hardly be expected that it can be much excelled by a one-step ship-lift. For all that, the German government can hardly decide to build further locks, because the inherent disadvantages of the lock system are as follows:

In the first place, the lock system, even with water-saving catch basins, is wasteful of water. For each ship which passes the locks about 2,000 cubic meters or over 70,000 cubic feet of water must be drawn out of the upper system, and this amount would not be available for a second lock system, by means of pumps. The net work which would have to be done to pass 24 vessels in 10 hours would be

$$\frac{24 \times 2{,}000 \times 36 \times 1{,}000}{10 \times 60 \times 60 \times 75} = 320 \text{ horse-power.}$$

On the German basis of three pfennigs = say 0.75 United States cent or 0.375 British penny per horse-power hour, this would amount to 96 marks = $22.85, or about £4.7 per day; which on the basis of 270 working days would be about 650,000 marks, $154,762, or £31,844

A mechanical ship-lift would not be dependent on the water of the upper level, and would call for but little power, as the weight would be largely counter-balanced. Including the power for towing the vessels in and out, opening and closing gates, and for lighting, etc., which would be about the same as already necessary under the lock system, the power required for a mechanical lift would be only about 60 horse-power, which would save in this particular alone about half a million marks (say nearly $120,000, or £26,750).

But not only in this particular would the cost of construction of a lock system be higher than that of a straight up lift; much more important would be the saving in earthwork; which, considering the steep drop at Leipe, would be enormous. It has also been shown, in the lock work already commenced, that the ground has a tendency to slide; and for this reason the slopes must be more easy than originally planned.

With a vertical lift it is possible, in order to get around this difficulty, to bring the lift so close to the border of the valley that only moderate earth workings would be necessary, and these with moderate slopes; and the connections above could be made by a bridge canal of reinforced concrete.

As regards rapidity of passage, the comparison is against the locks. The following figures may serve.

Outside of the waiting time before the locks, and the time of getting into position from the moorings, the time requisite for locking is as follows:

In	3 min. 50 sec.
Closing gates	1 min.
Lifting	6 min.
Opening under gate	1 min.
Out	3 min. 50 sec.

Total, about 16 minutes per single locking.

With four lockings and three rests, a vessel would require (supposing that all the work was properly and promptly done) seven such periods of time, that is, 112 minutes. Adding to this the waiting time, and we have 120 minutes, or two hours, per passage through the four locks. From this time, of course, there should be a deduction for the time which the vessel would require to sail or steam the same distance on the canal; but then the "waits" could be very considerable. To work the locks economically—that is, with the least possible water-consumption—to lock the greatest possible number of vessels, it would be necessary to have all four locks working equally, and always to have four vessels locking down grade and four up at the same time. For this reason the lock master would not begin to shift before he had four vessels at each end of the system. As the traffic in the two opposite directions cannot always be equal, there must be considerable time lost in waiting for the gates to open.

The time required for mechanical lift is figured as follows:

Through the aqueduct into the tank	5 min.
Closing gates	1 min.
Dropping the tank	5 min.
Opening gates	1 min.
Out	3 min.
Total	15 min.

To this we must add for passage from moorings 5 minutes; making the entire trip take about twenty minutes.

There is no long delay before transfer begins, as with the four-step lock; as for economical working of the plant it is necessary to have only one vessel ready for each direction.

A further advantage of the "all-mechanical" system is that without great increase of cost it is possible to build twin plants, thus nearly doubling the capacity. Among the various proposed lift-systems there are some which have taken such doubling up into consideration.

Building a ship-lift for the 118-foot rise at Leipe would be an engineering work which would mean an extraordinary step in the progress of internal navigation.

COAL BRIQUETTING IN THE YEAR 1909.

RECENT GOVERNMENT STATISTICS.

ACCORDING to Edward W. Parker, in the forthcoming volume on the "Mineral Resources of the United States," for the calendar year of 1909, issued by the United States Geological Survey, there was a marked increase in the production of manufactured or briquetted fuel in the United States in 1909, compared with the previous year.

"The quantity of compressed or briquetted fuel made in the United States in 1909 amounted to 139,661 short tons, valued at the works at $452,697. This was an increase over 1908 of 49,303 short tons, or 54.56 per cent in the quantity and of $129,640 or 40.13 per cent in value. When this domestic output of briquets, however, is compared with the 17,000,000 or 18,000,000 tons manufactured in Germany, it appears insignificant; but it does show that the industry after many years of trial and discouragement is getting started.

"The successful operation of a briquetting plant must depend upon its ability to utilize one or more of several classes of low-grade fuel and to produce an article which will compete in efficiency and price with raw or unmanufactured coal or with coke. When comparisons are drawn between the extensive development of the briquetting industry in Europe and the small beginning in this country, it must be remembered that in foreign countries the raw fuel is relatively high priced. In Germany, where the briquetting industry has been most highly developed, the raw fuel is not only more expensive, but also of lower grade than that of the United States. Labor is less expensive in European countries, and, moreover, the wasteful type of coke oven known as the 'bee-hive' is now practically unknown. Coal is coked in retort ovens, and nearly all of these are supplied with byproduct recovery equipment, which makes available a large supply of coal-tar pitch for binding material. These conditions are all favorable to the successful operation of briquetting plants.

"In the United States the industry is held back (1) by the large supply of cheap fuel, (2) by the higher cost of labor, which necessitates a higher price for the manufactured fuel, (3) by attempts, which have not yet ceased, to exploit secret processes for which extraordinary claims are made but which have not proved successful in commercial operation. If the byproduct recovery coke process had made more advances in the United States there would doubtless be available for binders a large supply of coal-tar pitch at prices which would induce the investment of more capital in the manufacture of briquetted fuel. There is an abundant supply of raw material which can be used for briquets, and in the utilization of which one of the greatest steps in the practical application of conservation principles could be made. This consists of materials which unless used in this way are wasted. The classes of low-grade fuel available for this purpose are: (1) anthracite culm; (2) slack coal from semi-anthracite, bituminous, and sub-bituminous coal mines, which does not possess fusing or coking qualities, and is therefore not available for the manufacture of coke; (3) lignite, which disintegrates on exposure to air, will not stand transportation to distant points, and cannot be stored for any length of time; (4) coke breeze, which possesses high fuel efficiency, but which, because of its small size, cannot be used as such either for domestic or other fuel; and (5) peat, which usually occurs at long distances from the coal supplies, and which, if properly prepared, makes an excellent fuel. The utilization of slack from bituminous coal which possesses coking qualities does not enter into the problem, as it can be and is used for making coke and can be used satisfactorily under boilers. A large quantity of powdered fuel is consumed each year in the manufacture of cement, for which even the lowest-grade fuels can be satisfactorily used. This consumption is growing rapidly, with the phenomenal advance in the manufacture and use of cement and concrete, but it is not enough to take care of the enormous quantities of slack produced in the non-coking coal regions, which is in many cases burned to keep it from 'cumbering the ground.'

"The utilization of coke breeze for briquetting purposes presents a problem distinctly its own; that is, the destructive abrasive effect which it has on the crushing apparatus and bearings of the machinery. It has been truly said that this material 'cuts like the diamond,' and the repair and replacement of parts of the machinery makes an expensive item in the attempts which have been made to use coke breeze in the manufacture of briquets. Two of the briquetting plants built in the United States have been for the purpose, primarily, of utilizing coke breeze. It is the custom to mix the breeze with some bituminous slack or anthracite culm, and it is found that such a mixture makes a more satisfactory briquet. The quantity of this coke breeze produced in the United States each year and practically wasted at the present time is from 2,000,000 to 3,000,000 tons."

In Mr. Parker's opinion:

"There is absolutely no reason for secrecy with regard to the constituents of patented binders. The field to be developed is so large that there is room for everyone, provided the expense is not inhibitive and the resultant briquet is a satisfactory fuel. The better educated the public becomes in the use of briquetted fuel the more rapidly will the industry develop, the most pronounced retarding element being the tendency to exploit secret methods of questionable merit instead of progressing along conservative lines in paths laid out by the experience of European countries.

"The production of briquets in the United States during the last three years in tons has been as follows:

Year.	Quantity.	Value.
1907	66,524	$258,426
1908	90,358	323,057
1909	139,661	452,697
Total	296,543	$1,034,180

"In order to meet with popular favor in this country briquets must be of a convenient shape for shoveling and for the circulation of air in the firebox. They must be of suitable sizes for the purposes they are intended to serve, and must possess sufficient cohesion to resist fracture and abrasion under rough handling. The very large briquets made in European countries, particularly in Germany, the chief reason for which is the advantage for stowage in bunkers of steamships and tenders of locomotives, are not adapted for use in this country. They must be handled and stowed by hand, and must be broken up before being shoveled into the fire. Labor conditions in this country make the cost of such handling prohibitive.

BINDERS.

"Experience in European countries and the investigations which have been carried on in the fuel-testing plant of the United States Geological Survey have demonstrated clearly that the successful briquetting of lignite may be accomplished without the use of any additional binding material, and that for the anthracite, semi-anthracite, bituminous, and sub-bituminous coals the most satisfactory binders are coal-tar pitch, gas-tar pitch, and asphaltic pitch, or inexpensive mixtures of which one or more of these are the principal constituents. The plants in successful operation in this country at the present time have added their experience to the evidence on this point. One plant began operating in 1910, using a binder of which oil obtained from the distillation of wood is one of the constituents, with apparently satisfactory results. Inorganic binders, though efficient in cementing quality, have the serious objection of adding to the ash but of adding nothing to the combustible character of the fuel. Pitch binders, on the other hand, contribute combustible material and do not increase the ash.

"Considerable attention has been given recently in Europe to the possibilities of sulphite pitch as a binder in the manufacture of briquets."

CROSS-TIE INDUSTRY IN UNITED STATES.

THERE was a substantial increase of about 10 per cent in the number of wooden cross-ties purchased for consumption by the steam and electric railroads in the United States in the calendar year 1909, as compared with the number purchased in 1908. In 1909 the total number of cross-ties of all kinds of wood, reported as having been purchased, was 123,754,000, costing $60,321,000 at the point of purchase, as compared with 112,463,000, costing $56,281,000 in 1908, and 153,700,000, costing $78,959,000 in 1907. The last date does not, however, represent the true standard of comparison, as it was one of unusual railroad development. The decrease in 1908 was about 26.8 per cent, but in 1909 the balance swung back to 80.5 per cent of the 1907 record, and was, as stated, an increase of about 10 per cent over 1908.

While there was considerable variation in the number of cross-ties purchased during the three years, the average cost per tie remained close to 50 cents. A significant feature is the fact that in 1909 there were 16,437,000 cross-ties reported as purchased for new track, as against 7,431,000 in 1908, and 23,557,000 in 1907.

The oaks continued in 1909 to lead by a wide margin all the other kinds of cross-tie material. Moreover, in the general return of the industry toward the 1907 record, owing to renewed activity in railroad extension, the oaks have come back faster than any other species. In 1907 the total number of oak cross-ties reported was 61,757,000; in 1908 it was 48,111,000; and in 1909 it was 57,132,000. During those years the proportion of oak cross-ties in the total number purchased ranged from 40 to 46 per cent. Southern pines, which numbered more than half as many as the oaks in 1907, dropped to considerably less than half in 1908 and decreased a little further in 1909. The figures are 34,215,000 in 1907; 21,529,000 in 1908; and 21,384,000 in 1909. In each year the oaks and southern pines together formed about two-thirds of the total number purchased. Douglas fir, while showing a material gain over 1908, was in 1909 still short of the number purchased in 1907, which was 14,524,000. In 1908 the total was 7,987,000, and in 1909 it was 9,068,000. From third place in the ranking order in 1907, Douglas fir dropped to fifth in 1908, but came back to third in 1909. In 1907 cedar, with 8,953,000, was fourth in rank; in 1908 it rose, with 8,172,000, to third place, displacing Douglas fir; but in 1909, with 6,778,000, it gave way to western pine, and took fifth rank. In 1907 chestnut was fifth, with 7,851,000; in 1908 fourth, with 8,074,000; and in 1909 sixth, with 6,629,000. Cypress held the sixth position, with 6,779,000 in 1907; seventh, with 3,457,000, in 1908; and seventh again, with 4,589,000, in 1909. Western pine was seventh from the top, with 5,019,000, in 1907; ninth, with 3,093,000, in 1908; and fourth, with 6,797,000, in 1909. Tamarack was eighth in rank in 1907 and 1909, but sixth in 1908. Hemlock was ninth in 1907 and 1909, but eighth in 1908. Redwood has held tenth place each year.

A marked increase is noticeable in the use of gum and beech woods. On the former, there were 15,000 cross-ties purchased in 1907, 262,000 in 1908, and 378,000 in 1909. The total number of beech cross-ties purchased was 51,000 in 1907, 193,000 in 1908, and 195,000 in 1909.

In the annual report to the President of the Board for Education by the Solar Physics Committee, which carries on work at the observatory at South Kensington, the committee call attention to the continuance of the difficulties under which, owing to defective accommodation and opportunities, the work of the observatory is still conducted. The great focal length of the mirror of the sun-spot spectrograph and the extended exposure necessary render the instrument extremely sensitive to vibration. As it is mounted on a site bounded on one side in its immediate vicinity by a main thoroughfare, it is, unfortunately, subjected to much disturbance. Further use of the instrument has been postponed until a better site can be utilized. The research on the astronomical origin of ancient stone monuments has been continued, and a number of circles, avenues, cromlechs, etc., in Cornwall, Wales, and Brittany has been investigated.

ENGINEERING NOTES.

Measures are now being taken to make the Rhine navigable between Basle and the lake of Constance. This part of the stream will thus be navigable for about 300 days in the year for barges and boats of high tonnage. The work which is now being carried out includes construction or rebuilding of barrages, channel rectifying, locks, and also hydraulic plants which will be operated by the various falls produced by the barrages. The localities of Schaffhouse, Neuhausen, Laufenburg, Rheinfelden, and others are interested. In this way the flow of the river will be regularized and it is also expected to obtain a large amount of power for the electric plants. The total amount of the falls is about 93 meters (310 feet), and this will allow of producing some 250,000 horsepower annually. An estimate of the outlay for the present work is given by Engineer Ihring as 150,000 marks per kilometer ($65,000 per mile) at the maximum figure. It is expected to pay a dividend of 3 to 3½ per cent on the capital by the sale of electric current in this region.

Zoelly Turbines in the German Navy.—We are informed that, in consequence of the excellent results obtained in destroyers fitted with the Zoelly marine turbine, the German naval authorities have ordered from the Germania Yard, Kiel, six more boats thus equipped. Official data as to the trials have not been published, but the figures given in the following report, translated from the Zeitschrift des Vereines Deutscher Ingenieure for March 26th last, are understood to be authentic. The torpedo boat G 173, built by Messrs. Krupp & Co., of Germaniawerft Kiel, carried out her trials on the measured mile in Eckenford Bay. This boat has a displacement of 650 tons, and is propelled by Zoelly turbines, designed by Messrs. Echer Wyss & Co., the total power being 16,000 horse-power. On trial, in about 25 meters of water, and in a slight wind, this boat reached a speed of 33.35 knots, the shaft power at this speed being 8,200 horse-power in each shaft at about 690 revolutions. G 173 is the first German warship fitted with Zoelly turbines.

Before the American Institute of Electrical Engineers, Messrs. C. F. Harding and A. N. Topping read a paper on headlight tests. The first portion of the paper is devoted to tests of the effect on the power of perceiving colored signals, of powerful headlights on locomotives. The second portion deals with detailed tests of various illuminants and headlights in the laboratory. The experiments were undertaken at the request of the Indiana Railroad Commission. As a result of exhaustive experiments it was found that powerful headlights on locomotives tended to produce "phantom signals," owing to reflections from the glass roundels and lenses, and that opposing brilliant lights of this kind obscured the classification signals to a marked degree; this was particularly true of green signals seen in the glare of a powerful searchlight the spectrum of which was rich in green. In addition, powerful electric headlights rendered it difficult to see obstructions on the line, capable of causing a wreck, in time for a high-speed train to be pulled up. The tests made in the laboratory dealt with the following illuminants: Magnetite arc, carbon arc, arc between carbon and copper electrodes, kerosene oil lamps, acetylene lamps. These sources were used in conjunction with parabolic mirrors and concentrating lens systems, and tests were made of the variation in intensity with distance. Polar curves of the illuminants studied and the results of spectrophotometric examination are also presented. It is shown that the magnitude of the illumination from a headlight depends not only on the luminous flux of the source used, but also on its polar curve of light-distribution. In general the lens type of projector has a better multiplying power than the reflector type.

SCIENCE NOTES.

Chauvenet has attempted to prepare metallic thorium free from oxide by using metallic lithium in place of sodium for reducing thorium chloride. By heating the mixture in an iron boat in a quartz tube from which air was carefully excluded, a product containing 96 to 96.6 per cent of metallic thorium was obtained. This, however, contained 3.2 per cent of thorium oxide which could not be removed. A purer product (96 to 97 per cent of metallic thorium) was prepared by heating thorium hydride (obtained by heating together thorium chloride and lithium hydride to 600 deg. C.) in a vacuum of 10 millimeters. The metallic borium thus obtained is black; it is not oxidized by air or by pure oxygen at atmospheric pressure, but is acted upon by oxygen under pressure. It takes fire with a luminous flame in fused potassium chlorate. It combines with chlorine to form thorium chloride, $ThCl_4$, with the liberation of 339.43 calories.

A communication has been received from Harvard College Observatory informing us that a new star, whose approximate position is R. A. 16 hours 31 minutes 4 seconds, Dec. —52 degrees 10 minutes 6 seconds (1875) was discovered by Mrs. Fleming in the Constellation Ara, on October 13th, 1910. It appears on twenty-one photographs taken at Arequipa with the 8-inch Bache and 1-inch Cooke telescopes, between April 4th, 1910, and August 3rd, 1910. The magnitude has been estimated as varying from 6.0 to 10.0 between these dates. The spectrum is quite faint, but shows on three plates the bright lines 5007, Hβ, 4670, H ν, Hδ, Hε, and Hζ, one of the plates showing also the bright line Hν. Apparently this object had passed into a nebulous condition before its spectrum was photographed. The star does not appear on forty-four photographs, taken between August 20th, 1889, and March 19th, 1910, although almost all of them show stars fainter than the twelfth magnitude, and two plates show stars as faint as the fifteenth magnitude. Of the sixteen new stars found during the last twenty-five years, thirteen have been found at Harvard, one by Miss A. J. Cannon, two by Miss H. S. Leavitt, from photographic charts, and ten by Mrs. Fleming from the Draper memorial photographs.

J. Duelaux and A. Hamelin have invented a modified mercury thermometer which they describe in the Journal de Physique. The variation of the angle of contact of the mercury in the capillary of a thermometer causes jerky movement, and consequent errors especially when the temperature is falling. Duclaux and Hamelin make thermometers, in which (as in the capillary electrometer) there is dilute sulphuric acid above the mercury meniscus. To avoid electro-capillary effects there is a recess full of mercury at the upper end of the capillary, and the mercury in the recess and in the thermometer bulb are connected by a platinum wire on the outside of the thermometer. The instrument thus produced is far more sensitive and accurate for minute changes than the ordinary mercury thermometer, as is shown by the following tests: (1) Raise temperature half a degree or less, then plunge in ice, and in every case the initial reading 0 deg. is obtained with an accuracy of 0.0001 deg. (2) Plunge the new thermometer in a basin of mercury by the side of an ordinary thermometer, note the readings of each thermometer every minute as the mercury basin is slightly warmed or cooled. The ordinary thermometer has a sluggish action by comparison with the new thermometer. Flat- and round-bore capillaries are equally successful. (3) A searching experiment is to observe the melting-point of ice under small + or — variations in pressure. The greatest pressure used is one-third atmosphere, the resultant change in fusing-point being 0.0017 deg., which is regularly given by the new instrument, but to which the ordinary thermometer is quite insensitive. The electrocapillary forces actually due to platinum-mercury or mercury-acid would produce errors of less than 0.0004 deg., which can be ignored.

TRADE NOTES AND FORMULÆ.

Plaster Casts Made to Resemble Ivory.—The object, thoroughly air-dried, is heated to 212 deg. F. and painted with melted stearic acid, heated to 212 deg. F., as long as it will absorb it.

Varnish for Gold Moldings.—Shellac 1,200 parts, sandarac 500 parts, gambooge 250 parts, sandalwood 200 parts, turpentine 150 parts, alcohol 5,000 parts. The sandalwood is treated separately in part of the alcohol and the rest of the ingredients added to the solution.

To Engrave Glass by Electricity.—Pour a layer of nitrate of potassium solution over a glass plate, place it horizontal and lay in this a platina wire connected with a battery. Then touch with the other electrode, also a platina wire (which is provided at the side with an insulating covering) those parts of the moistened plate that it is desired to etch.

Graining (Granular Gilding on Brass).—The polished and, in any practical manner lightly gilded objects, are rubbed off with a moist paste of silver powder, 6 parts common salt and 1 part alcohol, treated with the scratch-brush and then again lightly electro-gilded. The scratching with the paste must be continued until the graining plainly appears.

Cement for Plaster Figures.—Wet the fracture surfaces with clean water as long as it is absorbed and until the surfaces remain wet. Then stir calcined white plaster, with plenty of water, to a thin paste, continuing the stirring until the heating is over. By this means the plaster is "killed." One of the wet fractures is quickly coated very thinly with the killed plaster, the other surface pressed tightly against it and any plaster exuding carefully scraped off.

Plaster in Resemblance of Mahogany Wood.—To plaster is added 0.16 of its bulk in lime and it is saturated with green vitriol. Paint the surface with linseed oil boiled with oxide of lead and somewhat browned by the heating. The color tone is improved by coating with copal varnish. For floors, a layer of the above plaster, treated with green vitriol, about 2½ inches in thickness, then treated with oil and varnish, produces a surface resembling oak parquet.

Bright Bronzing of Plaster is effected by using goldbeaters' waste, which is rubbed down with honey in a paint muller. The plaster object is given a coat of linseed oil and the metallic powder applied with a rag. Mosaic gold can also be used, after it has been rubbed down with 6 parts of calcined bones; by means of a moist cloth, the mixture is applied to the article, then it is rubbed off with a dry cloth and finally smoothed.

Gold Lettering on Zinc.—Write on brightly polished zinc with a solution of 1 part chloride of platina and 1 part gum arabic, in 12 parts of water. The characters become black immediately by the formation of finely divided platina. Then transfer it, for a few seconds, into a potassium cyanide gold-bath, so that the plate acquires a thin coating of gold, and next place in water acidulated with nitric acid. The gold on the blank parts of the surface soon peels off and can be removed by a paint brush. The writing that appears in gold can be made more prominent by etching the ungilded parts.

Casting Metals.—Alloys of considerable hardness, which furnish very sharply outlined castings, are composed as follows:

	I.	II.
Copper	12	6
Lead	3	..
Tin	12	16
Antimony	3	..
Zinc	48	79

Alloy I. is prepared by alloying the lead and antimony, melting the copper and zinc in separate vessels, then pouring the copper into the zinc, turning in the lead-antimony alloy and stirring with a wooden stick. As this alloy possesses considerable hardness and engraves well, it is used extensively for making rollers for fabric printing and is, for this reason, known as roller metal.

Modern Gas Engines and Producer Gas Plants

By R. E. Mathot, M. E.

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